UNITED STATES DEPARTMENT OF THE INTERIOR

BLM LIBRARY
88076084

DRAFT ENVIRONMENTAL STATEMENT

VOLUME 1 OF 3

PROPOSED
1976 OUTER CONTINENTAL SHELF
OIL AND GAS LEASE SALE
GULF OF MEXICO

OCS SALE NO. 44

PREPARED BY THE BUREAU OF LAND MANAGEMENT

Curt Berklund

DIRECTOR

Bureau of Land Management
Library
Denver Service Center

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

#2364864 ID: 88076084

TD
195
.P4
G854
1976
v.1

Summary: Proposed OCS Lease Sale No. 44

(X) Draft ( ) Final Environmental Statement
Department of the Interior, Bureau of Land Management, New Orleans OCS Office

1. Proposed Oil and Gas Lease Sale, Outer Continental Shelf Gulf of Mexico
   (X) Administrative ( ) Legislative Action

2. Sixty-one tracts (103,305 hectares) of OCS land are proposed for leasing action. The tracts are located offshore Texas and Louisiana. If implemented, this sale is tentatively scheduled to be held in October, 1976.

3. All tracts offered pose some degree of pollution risk to the environment. The risk potential is related to adverse effects on the environment and other resource uses which may result principally from accidental or chronic oil spillage. Each tract offered is subjected to a matrix analyses technique in order to evaluate significant environmental impacts should leasing and subsequent oil and gas exploration and production ensue.

4. Alternatives to the proposed action:

   A. Hold the Sale in Modified Form
      1. Sale Modification Alternatives
         a. Delete tracts
         b. Substitute tracts

   B. Withdraw the Sale
      1. Energy Conservation
      2. Conventional Oil and Gas Supplies
      3. Coal
      4. Nuclear Power
      5. Oil Shale
      6. Hydroelectric Power
      7. Solar Energy
      8. Energy Imports
      9. Geothermal Energy
      10. Other Energy sources
      11. Combination of Alternatives

   C. Delay the Sale

   D. Alternative With the Proposed Action; Government Exploratory Drilling Before Leasing

Bureau of Land Management
Library
Denver Service Center

5. Comments have been requested from the following:

Department of Commerce
    National Oceanic and Atmospheric Administration

Department of Defense

Department of the Interior
    Bureau of Mines
    Bureau of Outdoor Recreation
    Fish and Wildlife Service
    Geological Survey
    National Park Service

Department of Transportation
    U. S. Coast Guard

Energy Research and Development Administration

Environmental Protection Agency

Federal Energy Administration

Federal Power Commission

State of Louisiana
    Office of State Planning

State of Texas
    Division of Planning Coordination

6. Draft Statement made available to Council on Environmental Quality and the public on May 26, 1976.

Visual Graphics for Proposed OCS Lease Sale No. 44

Western (Texas) and Central (Louisiana), Gulf of Mexico

Visual No. 1. Lease status, recreation, historic and archaeological resources.

2. Geologic and geomorphic features.

3. Upland soils and bottom sediments.

4. Undersea features, endangered wildlife and natural vegetation.

5. Coastal zone and offshore fisheries.

6. Surface currents.

General Gulf of Mexico

Visual No. 1. Submarine physiography of the Gulf of Mexico.

2. Tropical storms in the Gulf of Mexico and Atlantic Ocean 1954 - 1975.

3. Phytoplankton production and benthic plant distribution.

4. Gulf of Mexico pelagic and industrial fisheries.

5. Gulf of Mexico penaeid shrimps.

6. Transportation and coastal refining centers.

Note:

The regulations to which reference is made throughout this environmental statement are 30 CFR Part 250 and 43 CFR 3300, and Geological Survey OCS Orders Nos. 1 through 13 - Gulf of Mexico. These OCS Orders for the Gulf of Mexico may be obtained from the New Orleans OCS office. The CFR's cited may be obtained from the United States Department of the Interior.

TABLE OF CONTENTS

Table of Contents (continued)

III. ENVIRONMENTAL IMPACT OF THE PROPOSED SALE

DESCRIPTION OF PROPOSAL

Location and Reserves

The proposed sale under consideration includes 61 tracts offshore Texas and Louisiana. Tracts are summarized by location, expected type of production, acreage, distance from shore and water depth in Appendix A. These tracts, if leased, would add approximately 103,305 hectares, an increase of about 3%, to the current total of 3.3 million hectares (as of March 5, 1976) under federal lease in the Gulf of Mexico. Thirty-four of the tracts (approximately 49,472 hectares) are drainage tracts, 27 tracts (approximately 53,833 hectares) are development tracts and none are wildcat tracts. The tracts in this proposed sale range from three meters to 200 meters in water depth and from 4.8 to 175 kilometers from shore (Visual No. 1). One tract is located in water depth of 200 meters or more. Eighty-two percent of the tracts offered are gas prone, three percent are oil prone, and fifteen percent are oil and gas prone. The proposed lease sale would be made under Section 8 of the Outer Continental Shelf Lands Act (76 Stat. 462; U.S.C. Sec. 1337) and regulations issued under that statute.

The estimated undiscovered recoverable reserves which could be developed as a result of this sale amount to 100 to 200 million barrels of oil and one to three trillion cubic feet of gas. This would require an estimated 100 to 300 wells from 20 to 40 platforms and require approximately 161 kilometers of pipelines. It is estimated that the proposed leases may produce 7,500 to 30,000 barrels of oil per day and 90 to 360 million cubic feet of gas per day after development and production stabilizers. After consultations with industry representatives and the U.S. Geological Survey, it is not anticipated that any barging of production from offshore sites to onshore receiving facilities will occur as a result of this proposed sale.

Legal and Administrative Background

In 1953, the Outer Continental Shelf (OCS) Lands Act (67 Stat. 462) established Federal jurisdiction over the submerged lands of the continental shelf seaward of the state boundaries. The Act charged the Secretary of the Interior with the responsibility for the administration of the mineral exploration and development on the OCS. It also empowered the Secretary to formulate regulations so that the provisions of the Act might be met.

Subsequent to the passage of the OCS Lands Act of 1953, the Secretary of the Interior designated the Bureau of Land Management (BLM) as the administrative agency for leasing of submerged federal lands, and the U.S. Geological Survey (USGS) for supervising operations on the OCS. The Department formulated three major goals for the comprehensive management program for marine minerals. These are (1) The orderly development of the marine mineral resources to meet the energy demands of the nation. (2) The protection of the marine and coastal environment. (3) The receipt of a fair return for the leased minerals resources. These leasing objectives are based on legislative mandates as explained below.

(1) Orderly resource development is based on the OCS Lands Act which gives the Secretary the authority, in order to meet the urgent demand for oil and gas, to grant leases to the highest qualified bidder(s) on the basis of sealed competitive bids. (2) Protection of the marine and coastal environment is a direct outgrowth of the National Environmental Policy Act of 1969. This act requires that all federal agencies shall utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences in any planning and decision-making which may have an impact on man's environment. The products of BLM efforts in this direction are Environmental Impact Statements (EIS), Environmental Assessment Teams and contract studies designed to identify and characterize different types of environments and the problems that they face. (3) Receipt of fair market value has its base in two separate mandates. United States Code 31, Sec. 483 (a) obligates the Federal Government to obtain a fair return for public lands that are sold or leased. This is further implemented within the Executive Branch by the Bureau of Budget Circular A-25.

Tract Selection Process

Ordinarily, the proposed lease sale process begins with the Interior's Call for Nominations and Comments, an invitation to industry to designate specific tracts it is interested in bidding on if a sale is held, and to government agencies, private organizations and individuals to pinpoint for various reasons areas they believe should not be leased.

In the case of this proposed sale, the process begins with the tract selection announcement. The

changed procedure is authorized under Interior regulations which allow the Director of BLM, with the recommendation of the Director of the U.S. Geological Survey, to select drainage and development tracts without first calling for nominations and comments. Areas designated for the proposed lease sale include both "drainage" tracts—those which may share a producing oil and/or gas resevoir with adjacent tracts—and "development" tracts—those located on geological structures that have been known to contain oil and/or gas.

This type of sale is sometimes considered necessary for timely, orderly development in well-established, highly developed OCS leasing areas of the Gulf of Mexico. There have been 11 such selections and sales over the years in the Gulf of Mexico.

Leasing History

A total of 61 tracts containing approximately 255,163 acres (103,305 hectares) have been identified for potential leasing under this tract selection process. Ten of these tracts, containing 28,196 acres (11,411 hectares) have been leased previously. Seventeen of the tracts, containing 71,335 acres (28,869 hectares) that had been offered previously, received bids, but were ultimately rejected.

Geological Considerations

In February 1976, the Bureau of Land Management in New Orleans requested preliminary geological and geophysical data from USGS for the area included within the proposed sale. This evaluation was completed and the review by USGS covered the following: Resource estimates; geological information; geophysical data; actions planned to meet data needs; problems associated with exploration and development; and drainage of adjacent state lands. In the great majority of cases, the USGS data confirmed the recommendations as determined by the initial analysis of nominations.

Environmental Considerations

Responsibility for the initial tract selection lies with the New Orleans OCS office of the Bureau of Land Management and the U.S. Geological Survey under guidance furnished by the respective Washington offices as to Departmental policy and objectives. BLM and USGS also consider recommendations by the U.S. Fish and Wildlife Service regarding permits for exploration and minerals development.

Specifically, the tract selection process included a detailed analysis of all areas in which possible environmental degradation might occur as a result of oil exploration and development. The environmental resource categories receiving evaluation included:

Geology (bottom sediments and paleontology)
General climatology and seasonal weather patterns (visibility, winds, temperature, inversions, storms and precipitation)
Physical oceanography (sea temperatures, salinity, surface circulation including currents, waves, swells, and tides)
On and offshore outdoor recreation
Archaeological and historical sites Land Use
Socio-economics (population, employment, income, economic characteristics, agriculture, refining and processing facilities
Transportation networks
Air and water quality
Physical hazards (ocean dumping areas, military activities, existing pollution factors, undersea cables, ship transit lanes, shipwrecks and harbor areas)
Terrestrial soils and vegetation
Plankton, benthos, nekton and biological sensitive areas
Intertidal and reef communities
Endangered species
Areas of unique biological significance and marine life preserves
Terrestrial birds and wildlife
Marine birds and mammals
Commercial and sport finfish and shellfish
Beach and shoreline areas
Aesthetic and scenic values

The above basic information was then interpreted (using both written documentation and map overlays) in regard to the potential impacts or hazards which might affect individual resources as a result of offshore drilling and development, pipeline construction and oil spillage. From these interpretations "potential environmental hazard zones" were developed for use in the tract selection process. This type of procedure was also used in evaluating other considerations as well.

Other Considerations

Other areas which were reached and evaluated as part of the tract selection process were: use conflicts (defense warning zones, etc.), policy guidelines and possible drainage of reserves from state lands.

Activity Resulting from this Proposal in the Gulf of Mexico

The amount of commercial activity that may be generated in the Gulf of Mexico region as a result of this proposal is dependent on many variables. Chief among these variables would be the availa-

bility of capital, manpower, equipment and the amount of proven recoverable resource. Table D-1 summarizes the range of activities required to develop the estimated reserves within the proposed lease sale tracts.

TABLE D-1.—*Summary of the range of activities required to develop the estimated reserves within the proposed lease sale tracts*

	This proposed sale
1. *Estimated acreage, construction activity and reserves:*	
a. Acres (millions)	[1] 0.140
b. Production wells	100–300
c. Platforms	20–40
d. Miles of pipelines	100–200
e. Terminal storage facilities	0–2
f. Reserves:	
Oil (million bbl.)	100–200
Gas (trillion cu. ft.)	2–3
2. *Estimated annual crude oil transportation:*	
Transported by tankers (bbls./yr.)	0
Transported by pipeline:	
Minimum estimate (million bbls./yr.)	2.7
Maximum estimate (million bbls./yr.)	10.9
3. *Estimated volume of commercial mud and drill cuttings:*	
Assume 200 wells with average depth of 10,000 feet.	
Cuttings: 682 tons per well: Mud components: 230 tons per well, assume 10% consumed during drilling, balance reused in other wells.	
Drill cuttings (tons)	1,364,000
Mud components (tons)	506,000
4. *Estimated volume of produced formation water proposed lease sale area:*	
Assume 0.6 barrels formation water produced for each barrel of oil and condensate:	
Annual production (million bbls./yr.)	1.6–6.5
Total production (20 yrs) (million bbls.)	32–130
5. *Estimated total land use requirements for onshore facilities:* 0–32 hectares.	
6. *Estimated pipeline burial disturbance:*	
Offshore equals (where burial required) 4,921–9,841 cubic meters/kilometers.	
Onshore equals A zone 9–12 meters wide along pipeline right-of-way.	

[1] Estimated that 55% of the acreage proposed for offering in this proposed sale will lease.

Relationship of the Proposed Action to Existing and Prospective Offshore Oil and Gas Development in the Gulf of Mexico

This proposed action must be viewed as one part of a continuing activity that has been underway since the 1940's. Although primary emphasis concerning the description of the proposal and its potential environmental effects has been placed on this particular proposed sale in isolation from all previous activities of the same nature, it should also be put into the perspective of an ongoing offshore oil and gas development process. As of February 18, 1976, there have been 32 OCS oil and gas (and five OCS sulfur and salt) lease sales on submerged lands in federal OCS areas of the Gulf of Mexico (Table E-1).

TABLE E-1.—*Total acreage leased in Gulf of Mexico from the inception of OCS leasing activities through March 5, 1976*

Area	Acreage
Louisiana	8,361,383
Texas	3,169,572
Mississippi, Alabama and Florida	508,437
Total	12,039,392

Acreage currently under lease in Gulf of Mexico as of March 5, 1976

Area	Acreage
Louisiana	5,540,297
Texas	2,116,799
Mississippi, Alabama and Florida	404,757
Total	8,061,853

The Geological Survey has issued an approximate total of 1,222 pipeline permits on the OCS resulting in 3,758 kilometers of offshore pipelines. Currently, the Bureau of Land Management holds 398 permits on the OCS resulting in 8,098 kilometers of offshore pipelines.

As production declines in existing areas (during the next 5–10 years), some of the equipment, transporation facilities, pipelines, platforms and personnel can be utilized in new areas of activity. As existing areas of production declines, the pipelines in place for that system can be used for new production areas, adjacent or further from shore, thereby reducing the quantity of pipelines necessary to transport production from new areas to shore. This latter event has already been utilized in some areas offshore Louisiana. Likewise, a reduction in the quantity of onshore facilities such as treatment plants, refineries, storage facilities, etc., is made possible by utilizing existing facilities, equipment and technology.

Development of Proposed OCS Planning Schedules for Potential OCS Oil and Gas Leasing and the Department's Proposed Program to Accelerate OCS Oil and Gas Leasing Nationwide

Proposed OCS planning schedules are developed in order to project the timing, size and location of specific lease sales for an OCS leasing program. General sale areas are identified and, at a later date, tentative acreage figures are set for each proposed sale on the basis of broad resource knowledge. The goal of the proposed schedule is to provide for orderly development of OCS oil

and gas resources and to maintain an adequate contribution of OCS production to the national supply.

In developing a proposed OCS planning schedule, the Department considers the three leasing objectives that have been set for a Departmental OCS program. These objectives are: orderly and timely resource development, protection of the environment and receipt of fair market value. The overriding factor in planning for OCS leasing is to strive for a supply of oil and natural gas adequate to meet the demand for these resources, consistent with the protection of environmental values. This is the foundation of and justification for the existence of the OCS leasing program. The tentative acreage selection process that follows must consider the need to balance supply with demand. Acreage is tentatively selected in sufficient amount to engender industry interest and promote a fair market return.

The proposed OCS planning schedule is essential as a program planning document to enable the Department to proceed in an orderly and timely fashion with its process of considering the several proposed and possible lease sales identified in that document. The proposed OCS planning schedule aids the Department of the Interior in establishing the order in which areas will be examined and in planning the work assignments of personnel and the allocation of resources for the environmental and other studies enumerated. The proposed OCS planning schedule also serves to apprise federal, state, and local agencies, industry, and interested members of the public of the time frame for consideration of potential leasing in the identified areas of the OCS. The proposed OCS planning schedule is a flexible document that is subject to revision at any time. More particularly, the consideration of any proposed or possible sale is subject to being terminated, modified, deferred, or advanced.

In May 1974, the Department announced that it would prepare a draft environmental impact statement on the proposed program to accelerate OCS oil and gas leasing from three to ten million acres (1.2 to 4 million hectares) in 1975. This proposal considers the entire United States' Outer Continental Shelf. A draft environmental impact statement on this proposed program was published in October, 1974, submitted to CEQ and made available to the public for review and comment. Public hearings were held in February, 1975, on the draft statement in Anchorage, Alaska, Beverly Hills, California; and Trenton, New Jersey.

In November, 1974, the Department modified the goal of its proposed accelerated OCS oil and gas leasing program nationwide from leasing 10 million acres (four million hectares) in 1975 to holding six proposed lease sales (a proposed sale, as used herein, refers to a tentative sale as to which tract selections have been made for the purpose of preparing a site-specific environmental impact statement) in 1975 and six possible lease sales (a possible sale, as used herein, refers to a tentative sale which has been listed on a proposed planning schedule, but has not reached the tract selection stage of the consideration process) per year for the period 1976 through 1978, offering prospects in each frontier area (frontier area refers to any of the 17 recognized OCS areas in which there has been no prior Federal oil and gas leasing) by the end of 1978. Accelerated leasing remains an integral part of the proposal, but the specific acreage figure has been eliminated.

On November 14, 1974, a new proposed OCS planning schedule was announced by the Department of the Interior at a conference with the coastal States' Governors. The proposed OCS planning schedule, issued in November, 1974, was revised in June, 1975 (Figure F-1) to reflect changes in the timetables for considering certain possible sales listed on that schedule.

Some of the major resource, environmental and technological factors weighed in developing the proposed OCS planning schedule issued in November 1974 were as follows:

1. Review of the Council on Environmental Quality's environmental reports concerning the Gulf of Alaska and Atlantic OCS, and consideration of their ranking of areas by environmental risk and their concern for adequate regulation and utilization of technology. The Department has recently responded to this report, outlining the steps being taken on the basis of CEQ's recommendations.

2. Review of the results of Interior's survey of industry, state, and local governments, and interested members of the public concerning resource potential, leasing preferences, and matters of environmental concern. These results were published in June, 1974.

3. Collection and examination of considerable amount of resource data gathered in seismic surveys of these areas.

PROPOSED OCS PLANNING SCHEDULE

JUNE 1975
(REVISES NOVEMBER 1974 SCHEDULE)

SALE AREA		1974					
		J	A	S	O	N	D
SOUTH TEXAS	37		DES	PH		BSI FES	
CENTRAL GULF	38	ND			T		DES
CENTRAL GULF	38A	ND			T		DES
SOUTHERN CALIF.	35		T				
COOK INLET	1/	F	E	D	E	R	A
GULF OF ALASKA	39	BSI				C	ND
GULF OF MEXICO (GENERAL)	41						C
MID–ATLANTIC	40						
NORTH ATLANTIC	42						
GULF OF MEXICO (DRAINAGE)	44						
SOUTH ATLANTIC	43						
GULF OF ALASKA (INCLUDING KODIAK)	46						
BERING SEA (ST. GEORGE)	45						C
GULF OF MEXICO (DEEP)	47						
SO. CALIFORNIA	48						
MID–ATLANTIC	49						
BEAUFORT SEA	50						
OUTER BRISTOL BASIN	51						
NORTH ATLANTIC	52						
CALIFORNIA GENERAL INCL. WASH. & OREGON	53						
SOUTH ATLANTIC (BLAKE PLATEAU)	54						
BERING SEA (NORTON BASIN)	55						
GULF OF ALASKA – ALEUTIAN SHELF	56						
CHUKCHI SEA HOPE BASIN	57						

SALE AREA		1975											
		J	F	M	A	M	J	J	A	S	O	N	D
SOUTH TEXAS	37	N	Sale	.				S	A	L	E		H
CENTRAL GULF	38	PH		FES	N	Sale							S
CENTRAL GULF	38A	PH		FES	N			Sale					
SOUTHERN CALIF.	35		DES			PH	BSI		FES	N	Sale		
COOK INLET	1/	L		-		S	T	A	T	E		S	A
GULF OF ALASKA	39			T			DES		PH		FES	N	Sale
GULF OF MEXICO (GENERAL)	41	ND		T				DES		PH			FES
MID–ATLANTIC	40			C			BSI ND		T		DES		PH
NORTH ATLANTIC	42						C		ND	BSI	T		
GULF OF MEXICO (DRAINAGE)	44												T
SOUTH ATLANTIC	43							C			BSI ND		
GULF OF ALASKA (INCLUDING KODIAK)	46							BSI			C		ND
BERING SEA (ST. GEORGE)	45	ND				BSI		T					
GULF OF MEXICO (DEEP)	47												
SO. CALIFORNIA	48												
MID–ATLANTIC	49											BSI	
BEAUFORT SEA	50					BSI BSI							
OUTER BRISTOL BASIN	51					BSI							
NORTH ATLANTIC	52									BSI			
CALIFORNIA GENERAL INCL. WASH. & OREGON	53												
SOUTH ATLANTIC (BLAKE PLATEAU)	54												
BERING SEA (NORTON BASIN)	55												
GULF OF ALASKA – ALEUTIAN SHELF	56							BSI					
CHUKCHI SEA HOPE BASIN	57												

SALE AREA		1976											
		J	F	M	A	M	J	J	A	S	O	N	D
SOUTH TEXAS	37	E	L	D		I	N		F	E	B	R	U
CENTRAL GULF	38	A	L	E		H	E	L	D		I	N	
CENTRAL GULF	38A												
SOUTHERN CALIF.	35												
COOK INLET	1/	L	E		-		D	A	T	E		U	N
GULF OF ALASKA	39												
GULF OF MEXICO (GENERAL)	41	N	Sale										
MID–ATLANTIC	40			FES	N	Sale							
NORTH ATLANTIC	42	DES		PH			FES	N	Sale				
GULF OF MEXICO (DRAINAGE)	44			DES		PH			FES	N	Sale		
SOUTH ATLANTIC	43	T			DES		PH			FES	N	Sale	
GULF OF ALASKA (INCLUDING KODIAK)	46		T			DES		PH			FES	N	Sale
BERING SEA (ST. GEORGE)	45								DES		PH		
GULF OF MEXICO (DEEP)	47	C		ND			T			DES		PH	
SO. CALIFORNIA	48			C		ND			T			DES	
MID–ATLANTIC	49					C		ND			T		
BEAUFORT SEA	50							C		ND			T
OUTER BRISTOL BASIN	51									C		ND	
NORTH ATLANTIC	52											C	
CALIFORNIA GENERAL INCL. WASH. & OREGON	53								BSI				
SOUTH ATLANTIC (BLAKE PLATEAU)	54	BSI											
BERING SEA (NORTON BASIN)	55			BSI									
GULF OF ALASKA – ALEUTIAN SHELF	56												
CHUKCHI SEA HOPE BASIN	57							BSI					

SALE AREA		1977											
		J	F	M	A	M	J	J	A	S	O	N	D
SOUTH TEXAS	37	A	R	Y		1	9	7	5				
CENTRAL GULF	38	M	A	Y		1	9	7	5				
CENTRAL GULF	38A												
SOUTHERN CALIF.	35												
COOK INLET	1/	C	E	R	T	A	I	N					
GULF OF ALASKA	39												
GULF OF MEXICO (GENERAL)	41												
MID–ATLANTIC	40												
NORTH ATLANTIC	42												
GULF OF MEXICO (DRAINAGE)	44												
SOUTH ATLANTIC	43												
GULF OF ALASKA (INCLUDING KODIAK)	46												
BERING SEA (ST. GEORGE)	45	FES	N	Sale									
GULF OF MEXICO (DEEP)	47		FES	N	Sale								
SO. CALIFORNIA	48	PH			FES	N	Sale						
MID–ATLANTIC	49	DES		PH			FES	N	Sale				
BEAUFORT SEA	50			DES		PH			FES	N	Sale		
OUTER BRISTOL BASIN	51		T			DES		PH			FES	N	Sale
NORTH ATLANTIC	52	ND			T			DES		PH			FES
CALIFORNIA GENERAL INCL. WASH. & OREGON	53	C		ND			T			DES		PH	
SOUTH ATLANTIC (BLAKE PLATEAU)	54			C		ND			T			DES	
BERING SEA (NORTON BASIN)	55					C		ND			T		
GULF OF ALASKA – ALEUTIAN SHELF	56							C		ND			T
CHUKCHI SEA HOPE BASIN	57									C		ND	

SALE AREA		1978											
		J	F	M	A	M	J	J	A	S	O	N	D
SOUTH TEXAS	37												
CENTRAL GULF	38												
CENTRAL GULF	38A												
SOUTHERN CALIF.	35												
COOK INLET	1/												
GULF OF ALASKA	39												
GULF OF MEXICO (GENERAL)	41												
MID–ATLANTIC	40												
NORTH ATLANTIC	42												
GULF OF MEXICO (DRAINAGE)	44												
SOUTH ATLANTIC	43												
GULF OF ALASKA (INCLUDING KODIAK)	46												
BERING SEA (ST. GEORGE)	45												
GULF OF MEXICO (DEEP)	47												
SO. CALIFORNIA	48												
MID–ATLANTIC	49												
BEAUFORT SEA	50												
OUTER BRISTOL BASIN	51												
NORTH ATLANTIC	52	N	Sale										
CALIFORNIA GENERAL INCL. WASH. & OREGON	53		FES	N	Sale								
SOUTH ATLANTIC (BLAKE PLATEAU)	54	PH			FES	N	Sale						
BERING SEA (NORTON BASIN)	55	DES		PH			FES	N	Sale				
GULF OF ALASKA – ALEUTIAN SHELF	56			DES		PH			FES	N	Sale		
CHUKCHI SEA HOPE BASIN	57		T			DES		PH			FES	N	Sale

BSI Baseline Studies Initiated
C Call for Nominations
ND Nominations Due
T Announcement of Tracts
DES Draft Environmental Statement
PH Public Hearing
FES Final Environmental Statement
N Notice of Sale
1/ State May Conduct Sale

Baseline studies scheduled are contingent upon scientific personnel and equipment being available to perform the studies.
Sales are contigent upon technology being available for exploration and development. A decision whether to hold any of the lease sales listed will not be made until completion of all necessary studies of the environmental impact and the holding of public hearings; as a result of the environmental, technical, and economic studies employed in the decision – making process, a decision, may, in fact, be made not to hold any sale on this schedule.

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

U.S. DEPARTMENT OF THE INTERIOR
March 3 1849

Curt Berklund

Director,
Bureau of Land Management

This proposed OCS planning schedule does not represent a decision to lease in any of these particular areas. It represents only the Department's intent to consider leasing in such areas and to proceed with the leasing development of such areas if it should be determined that leasing and development in such areas would be environmentally, technically and economically acceptable. Thus, the modified program proposal to accelerate OCS oil and gas leasing entails leasing of some tracts in all of the frontier areas by the end of 1978.

The Department has revised the content of the draft programmatic environmental impact statement in light of the written comments received on that statement and oral comments submitted at the public hearings held in February, 1975. The final OCS programmatic EIS addresses the proposed program as modified in November, 1974, and includes a discussion and analysis of the proposed OCS planning schedule, revised June, 1975. The final statement was submitted to CEQ and made available to federal, state and local agencies, and interested members of the public in July, 1975. The Department announced that governmental agencies and the public would be able to submit comments on the final OCS programmatic EIS during the 60 day review and comment period following its publication.

As in the case of this proposed OCS oil and gas lease sale, the Department has committed itself to prepare a site-specific draft environmental impact statement for each OCS oil and gas lease sale that may be proposed. This is in addition to preparation of the programmatic EIS.

The approved accelerated leasing program that includes proposed sales in the Gulf of Mexico does not constitute a decision on this proposed lease sale. This site-specific proposal will be considered on an individual basis after the waiting period for the final site-specific EIS has expired, and only after the Department has considered the environmental, technical, and economic aspects of this particular lease sale proposal.

In the planning of the accelerated leasing program, a request for comments from all concerned parties on potential OCS oil and gas leasing appeared in the Federal Register in February 1974. The Bureau of Land Management and the Geological Survey reviewed all the responses received and, on the basis of these responses, determined several rankings of the 17 OCS areas, including the Gulf of Mexico, which were delineated in the request. The Central Gulf of Mexico was ranked first in a composite ranking of resource potential and preference. Four petroleum companies also ranked the 17 areas on the basis of environmental hazard. From least to greatest hazard, on a scale of one to ten (ten being greatest hazard), the Central Gulf of Mexico was ranked second.

This request for comments and ranking procedures was the first tier in the two-tier nomination system for OCS leasing, the second procedure being the tract selection process.

Relationship to Other Governmental Programs

Federal

Administrative and Regulatory Responsibilities

As indicated in the Tract Selection Process section leasing procedures and pre-leasing evaluations and analyses are the responsibility of the Department of the Interior—primarily the Bureau of Land Management and the U.S. Geological Survey. The U.S. Fish and Wildlife Service helps design environmental studies and acts in an advisory capacity through much of the leasing process.

Several agencies, including Interior agencies, are involved in regulatory aspects of offshore oil and gas operations which involve their program areas. Offshore structures require permits to assure that navigation is unobstructed by ascertaining that structures are properly marked to protect navigation. These permits are issued by the Department of Defense, Secretary of the Army (Corps of Engineers), and the Department of Transportation (Coast Guard), respectively. Establishment and enforcement of navigational safety regulations is also a responsibility of the Coast Guard. Pipeline safety is regulated by the Office of Pipeline Safety in the Department of Transportation. The Geological Survey also considers safety features of design specifications in approving pipeline applications. BLM grants the rights-of-way for pipelines through the Federal OCS.

The Federal Power Commission (FPC) and the Interstate Commerce Commission (ICC) regulate pipelines linked to interstate commerce, and the FPC sets the wellhead price of OCS-produced gas.

Permits for and regulation of oil discharges are under the jurisdiction of the Environmental Protection Agency (EPA), by the authority of the Federal Water Pollution Control (FWPC) Act, as amended in 1972. Both the Coast guard and the Geological Survey perform surveillances for oil spills and discharges.

The FWPC Act also provides for a National Oil and Hazardous Substances Polllution Contingency Plan for which EPA and the Departments of Interior, Transportation, and Defense all share responsibility.

In addition, the following Federal government agencies are represented on the OCS Research Management Advisory Board: Geological Survey, Fish and Wildlife Service, Environmental Protection Agency, and National Oceanic and Atmospheric Administration. The Board advises the Bureau and the Department in the design and implementation of environmental research projects to oil and gas exploration and development on the OCS.

The Board has been reorganized on a two-tier principle. The Board itself considers policy matters and is made up of Federal and State representatives in policy positions. An Environmental Studies Advisory Committee of the Board on technical matters, such as the composition of environmental baseline studies.

Other Federal Activities on the Gulf of Mexico OCS

Principal military use of the Gulf of Mexico OCS is by the Navy. Gunnery, aircraft, missile, and submarine exercises and activities presently take place in this region under the jurisdiction of the Commander, Eastern Sea Frontier. Air National Guard exercises also take place in designated corridors over the OCS.

State and Local

The Governors of all of the coastal states are represented on the OCS Research Management Advisory Board. Following are discussions of State and local programs and legislation which have a significant effect, or will be affected by OCS activities.

Coastal Zone Management

The Coastal Zone Management (CZM) Act of 1972 (P.L. 92-583), administered by the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce, provides grants-in-aid to States for the development and implementation of management programs to control land and water uses in the coastal zone. In order to qualify for implementation monies, a State must develop its management program within three years. The policy which the Act established is aimed at balancing protection of the coastal environment with development and economic interests. The Act also provides for consistency of Federal programs with approved State plans.

While the Act allows individual States much leeway in devising management plans and allocating responsibilities, both among State agencies and to regions and localities, the States themselves must approve the management plans. Therefore, the types of development permitted in the coastal zone, including any that might be associated with offshore oil and gas operations in the event this proposed sale is held, can ultimately be broadly controlled by the States.

Offshore terminals

Loop Inc., a consortium of six oil companies has proposed the construction of an offshore oil terminal to accommodate supertankers on the Louisiana OCS. They propose to place six single-point moorings in the Grand Isle area, blocks 52, 53, 58 and 59. The proposed lease tract nearest to this area is tract 61 (Mobile South No. 2 N658 E47) approximately 32 km south of the proposed site and 5 km east of the proposed fairway.

Seadock Inc., has proposed construction of an offshore oil terminal to accommodate supertankers on the Texas OCS. The proposed terminal will be located in the Brazos area blocks 439 and 459 and Galveston area blocks 429 and 460. The proposed lease tract nearest to this area is tract 1 (Brazos A-104) approximately 97 km southwest of the proposed site.

DESCRIPTION OF THE ENVIRONMENT

Geologic Framework

General Geology

Comprehensive discussions of the geologic framework of this region can be found in past Environmental Impact Statements:

For East Texas, OCS Sale No. 34, FES 74-14, Vol. 1 pp. 49-61 (USDI, 1974a).
For Louisiana, OCS Sale No. 36, FES 74-41, Vol. 1 pp. 55-83 (USDI, 1974b).
For South Texas, OCS Sale No. 37, FES 74-63, Vol. 1 pp. 61-86 (USDI, 1974c).

The Gulf of Mexico presently represents a subsiding ocean basin partially filled with sediments. The abyssal Gulf is underlain by a simatic (oceanic type) crust. Domes and diapirs, anticlines and faulting in the western Gulf create the greatest geophysical interest from the petroleum standpoint. The occurrence of salt domes has led to the division of the northern Gulf continental shelf into two provinces. To the east of DeSoto Canyon (General Gulf, Visual No. 2) the shelf is composed largely of a thick sequence of carbonate deposits. Although salt domes occur in DeSoto Canyon, the general decrease in the number of domes east of the Mississippi Delta implies that the underlying salt deposits thin eastwardly. High areas in the basement rocks created a barrier to deposition and may have limited the extent of Jurassic salt deposition to the east along the northern Gulf (Antoine, 1972).

Subsidence, sedimentation and erosion have built the submarine topography as depicted in bathymetric maps of the Gulf by Holland (1970) which is the major source of the bathymetry shown on the series of visuals with this Environmental Impact Statement (EIS).

The continental shelf is a gently sloping submarine plain (less than 1°) of varying width forming part of the border of the continent out to a water depth of approximately 148 m, at which point the continental slope begins. The continental slope has a steeper gradient (approaching 5°), extending from the continental shelf to the oceanic depths.

The environment of deposition of the continental shelf sediments is most significant in ints relationship to hydrocarbon production. Sediments deposited on the outer shelf and upper slope have the greatest potential for bearing hydrocarbons due to the following:

(1) This is the location where coarser, nearshore sands interfinger with the deeper-water marine shales, thus providing an optimum ratio of sandstone to shale. The shale forms the source-rock which provides the oil and gas and the sandstone provides the reservoir into which the hydrocarbons migrate.

(2) In this environment, the organic material deposited with the fine-grained clays and muds is preserved, and not oxidized as it might be in shallower, more turbulent water.

(3) It is at this location that the increased overburden of the prograding shallow marine deposits over the plastic salt and marine shales initiates salt flow which triggers the growth of salt domes and regional expansion faults thus providing traps for the hydrocarbons.

This environment, therefore, is the optimal one for providing the three ingredients for the successful formation and accumulation of oil and gas: reservoir rock, source beds and traps.

The continental slope in the northwestern Gulf consists of two parts, a relatively steep lower slope which breaks off abruptly along the Sigsbee Scarp and the upper slope (with 1-2° dip) which is characterized by a hummocky topography made up of small domes (seaknolls) and depressions. This upper slope occurs at about the 150 m bathymetric contour which delineates the Outer Continental Shelf—upper slope hinge line.

The structural grain and topography of the slope are controlled primarily by salt tectonics and the hummocks or hilly nature of the upper slope is due to diapiric salt structures. The top of the salt surface is identified on seismic and sparker records as a strong reflector or an envelope of diffraction patterns. Seismic reflection profiles across the continental margin of Louisiana and Texas suggest that most of the topographic "highs" on the upper continental slope are probably associated with salt intrusions or shale diapirs.

Status of Geologic Mapping in the Gulf of Mexico Area

To gain a better understanding of the geology of the Gulf of Mexico several visual graphics were prepared at a scale of 1:1,000,000 UTM (Universial Transverse Mercator) from a considerable amount of published and unpublished information.

A comparison of salt dome locations and the production trends on Visual No. 2 with the lease status maps (Visual No. 1) will give an overview of areas of success, failure and future potential in the area of the proposed sale. An intercomparison of the bottom sediment (Visual No. 3), geology (Visual No. 2) and undersea features (Visual No. 4) will give the viewer information on the origin and location of fishing banks and unique areas. A comparison of undersea features with the lease status maps will show where prospective areas are in relation to areas requiring special stipulations.

The source of most available data on coastal Texas is the Bureau of Economic Geology, University of Texas. This group, under the direction of Dr. W. L. Fisher (see Bureau of Economic Geology Annual Reports 1972 thru 1975) has compiled environmental geologic maps at a scale of 1:24,000 for the seven coastal areas of Texas covering a strip of the coastal zone approximately 80 kilometers wide. These maps include the areas from 16 to 24 km offshore and 56 to 64 km onshore. These maps are published as regional maps at a scale of 1:125,000.

The geologic information used for Visual No. 2 was taken from several generalized sources including:

Geologic Map of Louisiana by R. J. LeBlanc, 1948
Geologic Map Coastal Louisiana by D. E. Frazier, 1967
Geologic Map of Mississippi by Miss. Geological Survey, 1969
Geologic Map of Baldwin County, Alabama, P. C. Reed, 1971
Tectonic Map of Louisiana, Pl. II, Lafayette Geological Soc. 1973
Production Trend Map Pl. I, Lafayette Geological Soc. 1973
Production Trend Map of Gulf, USGS, Metairie, La. 1974
Oil & Gas Map of Louisiana, La. Geological Survey, 1973
AAPG Tectonic Map, Gulf Coast, 1972
GSA Bull. Vol. 83, Wilhelm & Ewing, 1972
AAPG—U.S. Geological Highway Map (Texas), H. B. Renfro, 1973
Offshore Louisiana Oil & Gas Fields, Lafayette Geological Survey, 1970
AAPG bathymetric Map, Gulf of Mexico, W. C. Holland, 1970
Geologic Map of Louisiana, Busch et al., 1974
Physiographic Overview of South Louisiana, 1972
Atlas Inventory of Basic Environmental Data
U.S. Dept. of the Army, 1972
Subsurface Fault and Salt Dome Map, Environmental Atlas for South Central Louisiana, Gagliano, et al., 1973
Geologic Map of Florida, Vernon and Puri, 1964

It should be noted that Louisiana is particularly in need of a modern compilation of coastal Geology. Busch et al. (1974) have compiled a physiographic map of the Atchafalaya Basin and a portion of the lower Red River Valley. Another study for south-central Louisiana is the Corps of Engineers-Sea Grant Study, by Gagliano et al. (1973).

Geologic Hazards

A number of important geologic hazards occur in the offshore Gulf of Mexico. In the Texas offshore area the possibility of blowouts exists due to the presence of shallow (about 328 m depth) gas deposits within the sediments. Deeper high pressure zones can also cause blowouts during the drilling operation. A third hazard is a soft plastic sea floor laced with surficial faults which can present unstable foundations for rigs. A fourth hazard can occur in rough sea floor conditions where coral heads, sharp reefs and structural troughs occur. Damage to the rig in areas of poorly described roughness can occur by jamming the legs or having legs slip off rough surfaces. The problem of locating rigs on a soft plastic sea floor is compounded in offshore Louisiana along the steeper slopes of the Mississippi River delta primarily off Main, South and Southwest Passes (Fig. A-1).

SUBSIDENCE

The apparent rise in sea level and/or land subsidence is a hazard along the low coastal lands of Texas and Louisiana.

Along the coastal lands subsidence can not easily be separated from the effects of the rise in sea level because either action allows encroachment of the ocean. Causes of the rise in sea level are generally attributed to the melting of glaciers and polar icecaps.

Land subsidence is generally attributed to extensive pumping of ground water and petroleum which causes a decline in the piezometric pressure in the porous rocks allowing once saturated beds to compress. Subsidence can also occur from sand and sulphur pumping and tunnel mining, however, this is rare in the areas under consideration.

National Ocean Survey (NOS-NOAA) has maintained tide gauges and sea level data in the Gulf for many years. Data on three long term stations are shown below.

Site	Years monitored	Sea level change (meters)
Pensacola, Fla.	47	0.16
St. Charles, La.	31	0.39
Galveston, Tex.	62	0.43

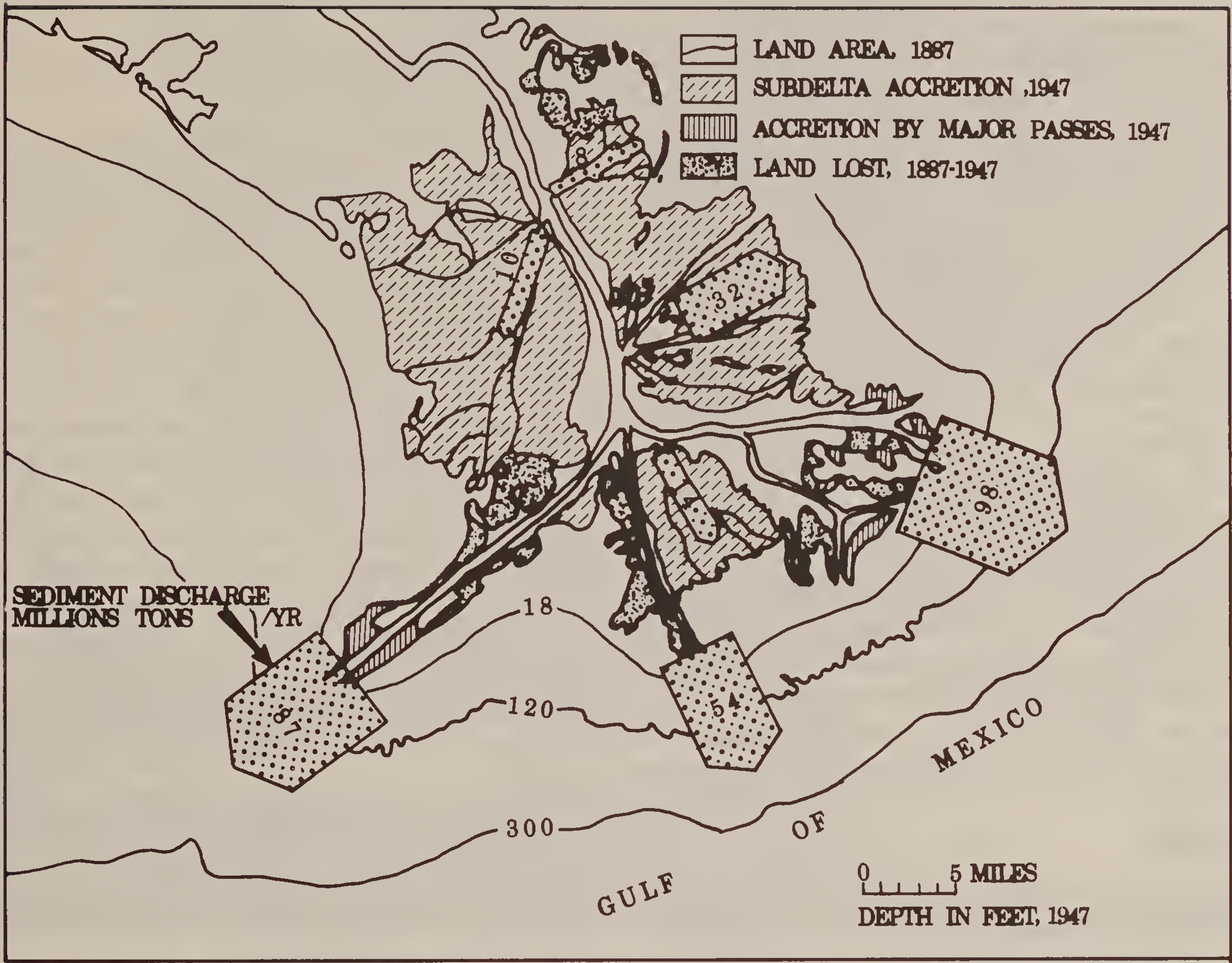


Figure A-1 Relative sediment discharge and land accretion in the active birdfoot delta of the Mississippi River.

Land subsidence studied by Turner et al. (1966) for the Houston area is severe and as shown in Figure A-2 reaches as great as 1.6 m of subsidence in the past 25 years. This is predicted to continue in some areas to as great as 3.4 m of subsidence, bringing areas below sea level in Baytown and Texas City, Texas.

Mud slides

Recent studies of mud slide hazards in the Mississippi Delta were conducted by the U.S. Geological Survey with the cooperation of the Coastal Studies Institute of Louisiana State University.

Figure A-3 delineates areas within which adverse foundation conditions can exist. It has been possible to cope with some areas of unstable conditions through extensive engineering design on the platforms.

Relatively rapid sediment movement can occur both in the lateral and vertical directions placing a structure in critical trouble. These movements, which may cover larger areas, pose a type of hazard to sea floor structures which is analagous to that posed by landslides to structures onshore, except that offshore they may occur on slopes which are almost negligible.

Some of the pioneering work in this field by Shell Oil Company suggests that in some cases fluctuating pressures within the upper 32 m of sediment caused by storm waves may trigger a sediment failure. Other investigations conducted at the Coastal Studies Institute indicate that the content of dissolved and undissolved gases in sediments may play an important role in their instability.

Earthquakes

Of lesser importance in the Gulf of Mexico is the risk from earthquakes. No known damage has been recorded from earthquakes on an offshore oil platform or installation in the Gulf of Mexico.

Seismic risk areas were originally designated for all parts of the United States in 1947 by the Coast and Geodetic Survey and revised several times since then. Seismic risk is expressed in arbitrary numbers from 0 to 3. They are based on historical data considering only the intensity of an earthquake, not the frequency of occurrence, and express the anticipated damage that would occur in that area.

Zone 0—No damage
Zone 1—Minor damage
Zone 2—Moderate damage
Zone 3—Major damage

In the western Gulf of Mexico, seismic risk is zero (Algermissen, 1969). This appears to be a rather unique area due to the lack of seismicity. No earthquakes of any notable intensity have been recorded for this area and only two earthquakes of notable intensity have occurred in the Gulf near this area; one north of Vera Cruz, Mexico and one southeast of the leasing area in over 600 m of water near 93° W and 27°30′ N. Neither of these earthquakes produced damaging tsunamis and neither were considered well located events.

Fault displacement, hydrocarbon seeps and seep mounds

Acting faults, gas seep areas and seep mounds pose dangers to offshore seabottom operations, however these hazards are some of the most obvious anomalies recorded by geophysical surveys for bottom hazards. Active faults in hydrocarbon producing areas such as the vast salt dome province in offshore Louisiana (Central Gulf, Visual No. 2) are generally associated with hydrocarbon seeps (normally gas seeps) and unstable seep mound areas which can often grow to heights of more than 16 m. Areas underlain by salt domes, such as the Flower Garden Banks, Claypile and Stetson Banks (Western Gulf, Visual Nos. 2 & 4) are typical areas where active faults, gas seeps and seep mounds have been surveyed. Since these features are notable on side-scan and high-resolution seismic data, these survey techniques are routinely used to locate these hazards.

Active fault displacements, gas seeps and seep mounds are generally considered an order of magnitude less hazardous than gas charged sediments and high pressure gas zones due to the recognizability of these former features on survey records. Gas charged sediments, high pressure gas zones and gas saturated sediments in delta areas are significant potential hazards however. Although geophysical techniques cannot detect high pressure zones directly, processed survey data frequently reveal velocity and amplitude anomalies which appear to correlate with the geopressured zones.

Bathymetric prominences and steep slopes

Rough sea floor conditions where coral growth, reef scarps and troughs occur can be hazardous to pipeline installations and installations of offshore platforms. Shipwrecks and large artificial reefs

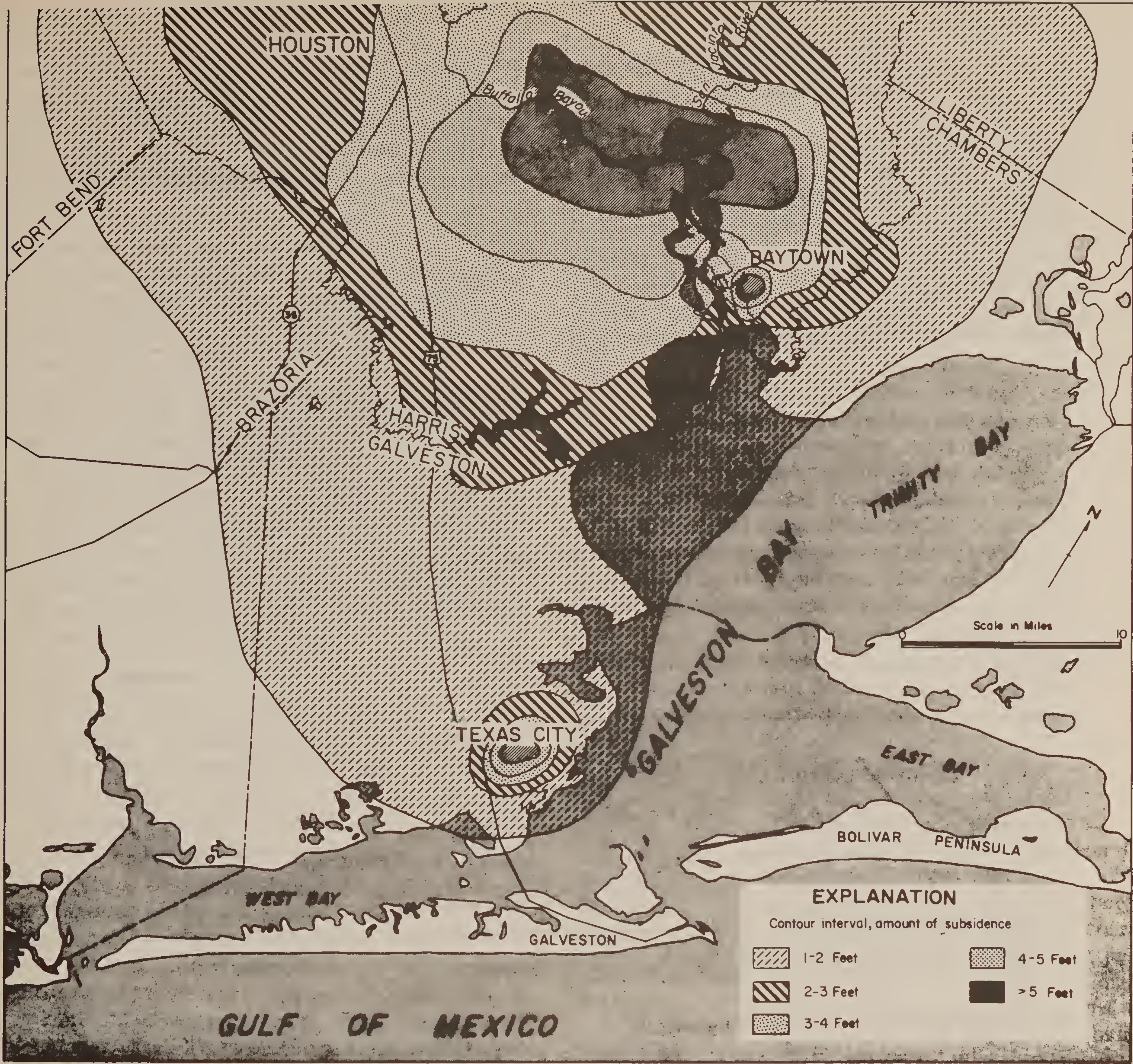


FIG. A-2 Land-surface subsidence in the Houston area (1964). After Turner et al. (1966).

Fig. A-3 MAP SHOWING ZONES OF RELATIVE BOTTOM SEDIMENT STABILITY. (U. S. Geological Survey, 1974.).

must also be avoided as obstructions in place as well as a movable hazard if the area is disturbed by high currents and bottom instability during hurricanes. These problem areas can be located by modern geophysical equipment used in hazard surveys.

Rating of the hazards

It is not entirely realistic to rate hazards since they vary greatly in areal extent, magnitude, intensity, chance of occurrence and degree of mitigation. Each hazard must be studied on a case by case basis in each particular area. However, an attempt to rate the hazards in this region for offshore pipeline and platform installation with these qualifications is presented in Table A-1.

During its review of applications to drill, the USGS informs the applicant of all current data concerning geologic hazards in the proposed area of operations, and requires that the applicant submit an operation plan which outlines procedures intended to deal with these hazards.

Bottom Sediments

Sedimentation in the Gulf of Mexico has been complicated by transgression and regression of the shoreline in response to changes in sea level and/or tectonic movement of the adjacent land mass or sea bed. The overall pattern of deposition is one of transgression interrupted by minor regressions. The result of this is a sequence of continental, deltaic or paralic, and shallow water sandstones, siltstones, and shales past, particularly in the Late Tertiary, sea level has been lowered or raised in response to increased or decreased glaciation. This has tended to upset the normal progradation of the shoreline, but at the same time it created extensive salt marsh areas on the now submerged continental shelf. Decay of buried organic matter from brackish water marshes are thought to be the primary source of the hydrocarbons found on the continental shelf.

The Mississippi Fan dominates the north central Gulf region of the Gulf of Mexico (Central Gulf, Visual No. 2). This thick accumulation of primarily Quaternary alluvium extends over a 414,400 square kilometers area including parts of the shelf, slope, rise and abyssal floor. Bottom gradients range from two degrees near the apex to about 0.3° at the outer margin more than 644 km to the southeast. Within this slope regime the greatest change in gradient occurs roughly at the 2,500 meter isobath and arbitrarily divides the fan into upper and lower segments (Huang and Goodell, 1970).

Historically, the site of active deltaic build-up along the Louisiana coast has shifted several times during the past million years. Kolb and van Lopik (1966) identified at least seven subdeltas of the Mississippi Delta complex. The river's modern ''birds-foot'' delta, the Balize Lobe, extends underwater almost to the continental slope and represents the uppermost part of the Mississippi Fan.

The Mississippi Fan and major portions of the abyssal plain and continental rise contain sediments that were transported in part by turbidity currents and in part deposited pelagically. Sediments in these areas have been derived from the northern and western shelves and slopes; however, the bulk has been derived from the Mississippi Delta. The midwestern and southwestern Gulf have sediments that are more pelagic in origin. Their carbonate content is high and is made up in major part by foraminifera tests. A low accumulation rate is assumed for this area based on the observed high degree of bioturbation.

The Alaminos, Old Mississippi and DeSoto Canyons are inactive canyons in which the upper part of the sediment column does not reveal typical submarine canyon characteristics but a rather homogeneous ooze type sediment as filling.

Relief features associated with the shelf edge and slope have been reported by Uchupi (1967), and Bergantino (1971), (General Gulf, Visual No. 1).

Sediment maps for the Gulf of Mexico (Visual No. 3) have been compiled principally from a map by John Grady (1970). Additions to John Grady's data have been made principally in the location of hard banks, coral banks, gravel and shell areas taken from other sources such as commercial fishing bank maps, industry surveys and personal communications with university researchers, sports and commercial fishermen.

Localized sediment maps for the areas south of Timbalier Bay to Grand Isle (Gulf Universities' Research Consortium, 1974) and Mississippi Sound (from Eleuterius, 1974) contain detailed information useful as a supplement to the regional sediment map by Grady (1970).

According to Curray (1960) and Shepard (1960), the surface sediments of the shelf are mainly

Table A-1 HAZARDS ARE LISTED WITH A PROPOSED RATING OF GREATER TO LESSER DEGREE

Hazard	Ease of Identification	Ease of Mitigation
Unstable bottom, steep slopes, gas charged, hurricane triggered	Yes (Mud slide areas)	No (hazardous to pipe-lines) extensive pilings for platform strength
Unstable bottom, steep slopes, gas chaged, gravity triggered	Yes (Mud slide areas)	Same as above
Gas charged or geopressured zones	Variable	No (blowout preventers) semi-submersible or drillship are safer than platforms
Fault displacement, gas seeps and mounds	Yes Geophysical surveys	Yes (moving off - directional drilling)
Rough sea floor, shipwrecks	Yes Geophysical surveys	Yes (moving off - directional drilling)
Karst topography	Yes Geophysical surveys	Variable
Earthquakes	No After the fact	Variable - affects coastal zone
Subsidence	Variable	Variable - affects coastal zone

Holocene or Pleistocene in age and are products of the marine transgression (depositions during the rise and fall of the sea level) following the Wisconsin glaciation.

From the Rio Grande River northward, Holocene sediments are generally thin and thicken only at the mouths of rivers with the particular thickening of over 115 m in the Mississippi Delta area. Holocene sediments (Visual No. 3) are usually unconsolidated along the bays, estuaries and shoreline of Texas in comparison to the Pleistocene sediments. The top of the Pleistocene in some areas is recognizable on high resolution seismic records. Sea floor composition from Port Isabel to Port Aransas is generally silty clays with sand zones near shore and some sizable areas of shell and silt particularly in Corpus Christi, Galveston and Aransas Bays. From Port Aransas to the Texas-Louisiana boundary the sediment zones become more varied with longer zones of sand and silty sand with less silty clay present. Part of this increased complexity may be due to the general increase in the number of samples that were collected. Few areas of gravel exist, however, and dredging of shell has a commercial value in Texas state waters. Sediment deposits in the southern area have the unique characteristic of alternating bands of coarse and fine sediments paralleling the coast (Curray, 1960). The coarse sediments are presumed to be relict shallow water deposits whereas the finer sediments are Holocene shelf deposits. Four depositional zones can be recognized in the northeast Texas OCS area. Zone One consists of layered sand from the beachline to the forty foot depth; Zone Two consists of alternating thin layers of sand and mud of irregular widths; Zone Three consists of mud flat deposits with shell banks and shallow water faunal remains and Zone Four consists of homogeneous clays and silts with deeper water faunal forms.

A number of undersea features are shown in Visual Nos. 3 & 4. Many of these features are known to have unusual or notable sedimentary conditions and are generally regarded as preferred fishing areas or banks. Names of most of these features are of local use and have no official federal acceptance. Visual No. 4 shows approximate locations of shipwrecks which could also have archaeological significance as well as fish havens, fishing banks, rocks, holes and reefs. In the western Gulf of Mexico a striking number of banks are considered snapper and grouper fishing areas and usually prove to have been caused by the upward thrusting of piercement salt domes. The origin of East and West Flower Garden Banks is the joint growth of upward moving salt plugs and the reef building coral.

The bank which has been studied to the greatest extent is the West Flower Garden. A report "The Geology of the West Flower Garden Bank" by Edwards (1971), gives a complete history of studies there. A recent study by several investigators discussed the geology, geochemistry, sediment distribution and biology of a portion of the bank under the auspices of the Flower Garden Ocean Research Center (FGORC) during 1972. This study concentrated on the high part of the bank in the area of the living reef building coral. A wealth of excellent photographs and valuable data was collected during these research missions by Bright & Pequegnat (1974).

The origin of other major banks has not received as extensive research; however, Stetson Bank appears most like the Flower Garden Banks (Bright & Pequegnat, 1974). As exploration in this part of the Gulf continues, many new unique bathymetric features are being discovered. Figure A-4 compiled by Bright (1974), shows over sixty such banks, with most of them clustered along the 183 meter depth contour offshore of western Louisiana and eastern Texas. This alignment also coincides with the Pleistocene gas deposit trend along the edge of the shelf. Major petroleum interest is being devoted to these areas and additional study of these areas seems inevitable. Detailed maps of fishing banks shown in western Gulf, Visual No. 4 have been prepared by Texas A & M University and DECCA Surveys, and are available in their report of Texas fishing banks to the Bureau of Land Management, New Orleans.

Various alignments of banks are obvious along the Texas coast. It is presumed that the alignment of these banks constitutes a record of ancient shorelines (Curray, 1960). Many of these banks were the result of a nearshore environment; hence, the oyster, clam and other shell deposits. In other cases, lagoonal mud deposits and nearshore beach strands have been preserved. In most cases, these banks were presumed to have developed during the Pleistocene and Holocene; however, research of many of these features has been either cursory or nonexistent. Many banks probably existed during various stands of sea

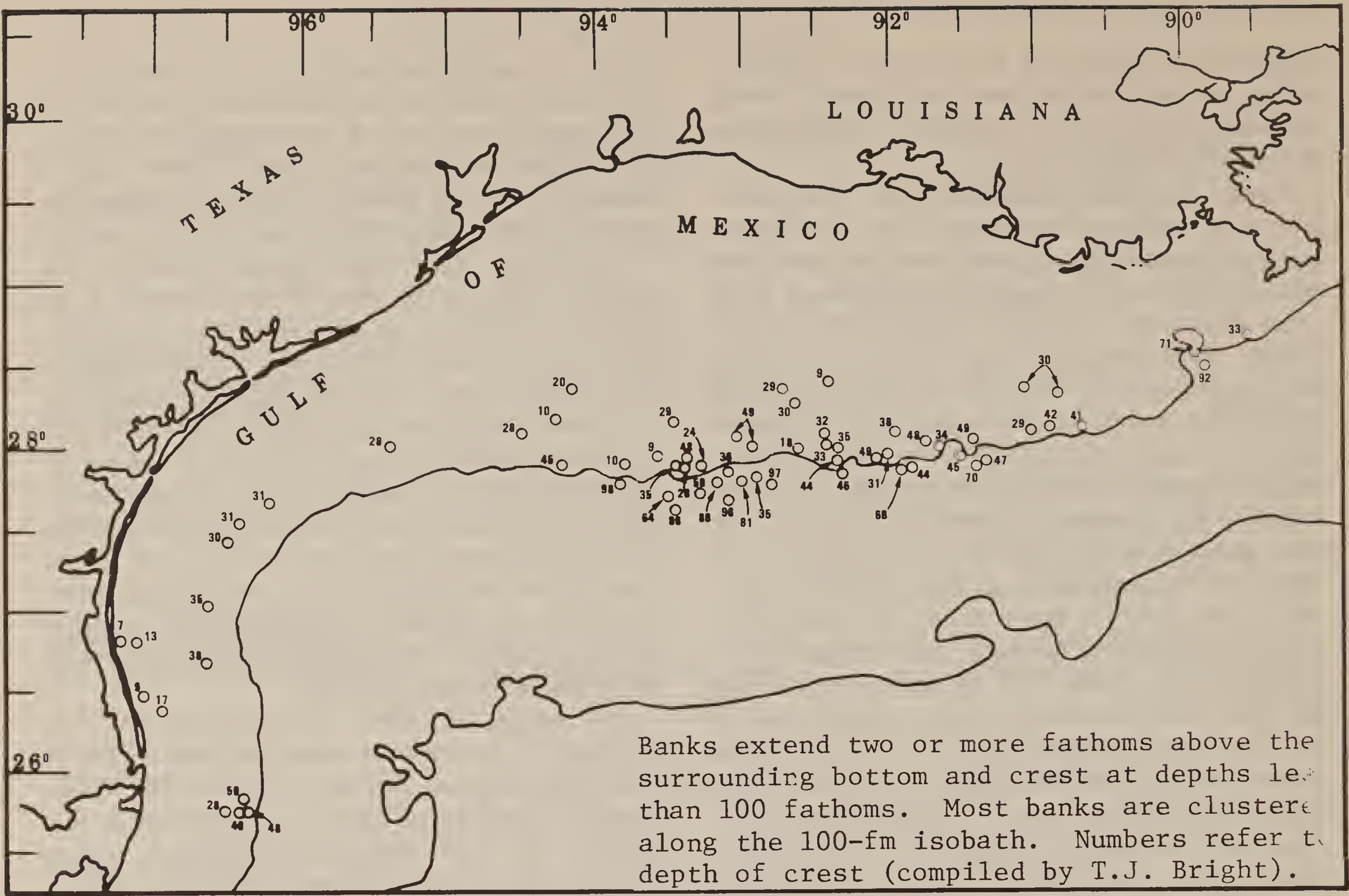


Figure A-4 Distribution of Submarine Banks in the NW Gulf

level in late Pleistocene where shell growth or calcareous cementation of sediments occurred. This condition could have occurred out to the present 100 m water depth (Fig. A-5). As the beach lines migrated due to changes in sea level, the unconsolidated barrier deposits or topographic highs along the beaches were destroyed and reworked; leaving the shell beds, cemented sands and clays as bathymetric highs due to their resistance to erosion.

Petroleum Geology

The most prominent structural anomalies in the northwestern Gulf are salt domes (Central Gulf, Visual No. 2) and a series of regional, down-to-the-Gulf faults which have materially affected sedimentation across them. Less common are deep seated, low-relief up-lifts and shale domes (Western Gulf, Visual No. 2). These structural features are related to the presence of an underlying salt basin and the Cenozoic sedimentary wedge which has gradually advanced seaward across it.

The abundant salt dome structures around which most of the oil pools off East Texas and Louisiana have formed are rare off South Texas. Although salt is thought to be present at depth, it has not formed diapirs so freely for reasons not well understood. Large salt structures are present in deeper water near the base of the slope, but they are not structurally similar to the piercement domes to the northeast, and their trapping capabilities are not known. Several large, linear deep-seated anticlinal structures are present near the mid-shelf area but little can be said of their origin on the basis of available seismic records. In the coastal area from Corpus Christi to Matagorda Bay, a number of domes with cores of shale are present. Their extent is not fully known, but hydrocarbon production has been obtained from at least a few.

A series of regional faults commonly called "growth faults" are present in the Texas-Louisiana subsurface. They are aligned approximately parallel to the coast. These are normal faults, long and arcuate in the horizontal plane, with large amounts of vertical displacement downwards into the coastal basin. Rock units commonly show greater thicknesses on the downthrown sides of these faults, thus fault movement and deposition must have been essentially contemporaneous. The downthrown section acted as a topographic depression for localized deposition.

During the Miocene, Pliocene and Pleistocene, large volumes of sediment derived from the Mississippi River system were supplied to the offshore Louisiana area. The Texas shelf, at the same time, received smaller volumes of sediment because it was on the western border of the Mississippi River depocenter.

Since natural production of oil and gas frequently occurs along the continental shelf-slope break, the progradation of the north-central Gulf depositional regime has resulted in the migration of this production zone seaward, developing a series of progressively younger bands of trends. Central Gulf and Western Gulf, Visual No. 2, shows the Late Tertiary and Quaternary production trends which underlie this area.

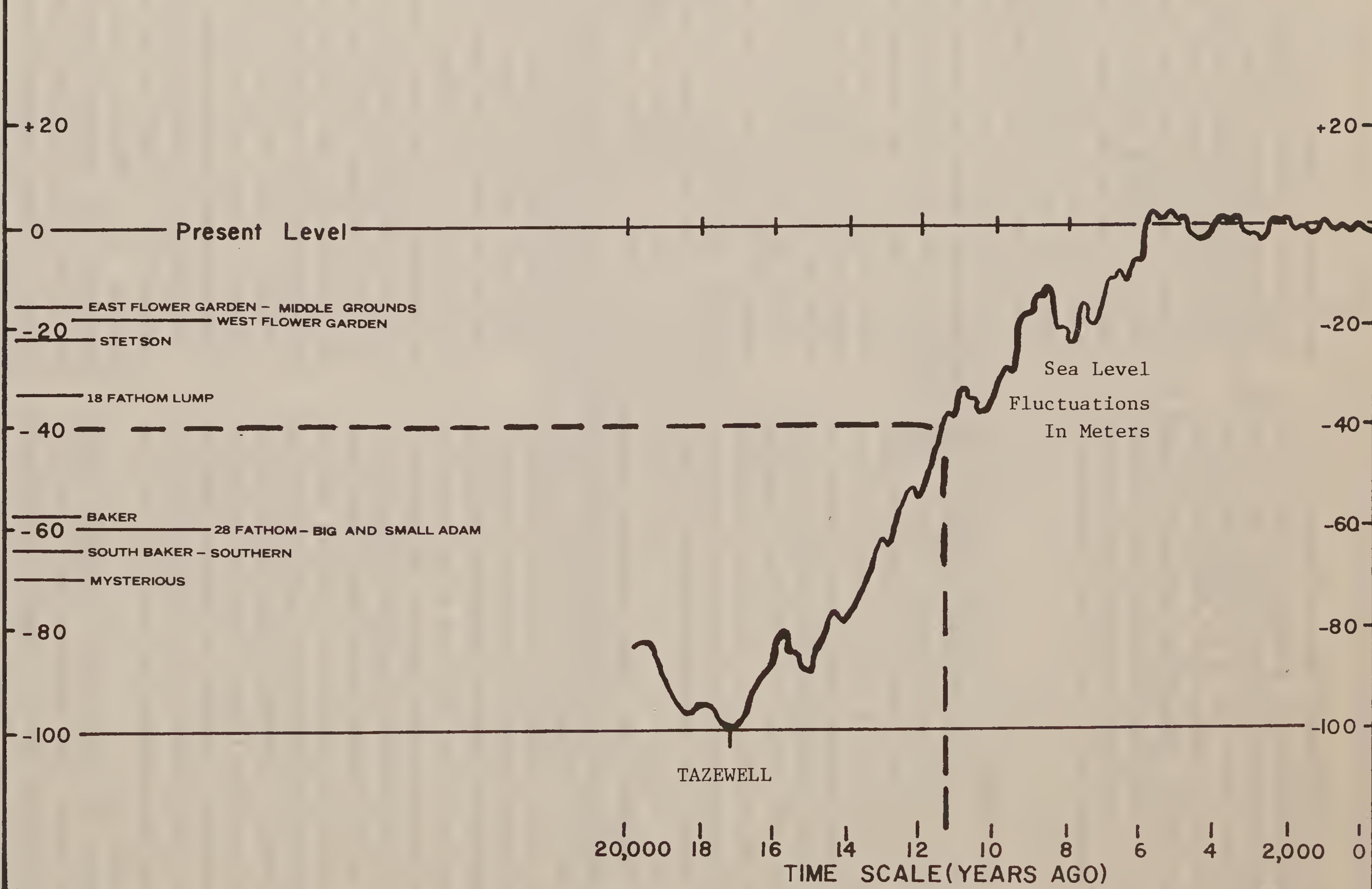
There are approximately 366 fields on the Federal OCS of the Gulf of Mexico. Of these, 232 primarily produce gas and 94 primarily produce oil. Production depths range from about 328 m to 9515 m, with most production occurring between 2625 and 3938 m. USGS records show that 3.613 billion barrels of oil and condensate and 0.68 trillion cubic meters of gas have been produced from Federal OCS lands as of January 1, 1975.

The most prolific offshore production comes from the Miocene of the eastern Louisiana OCS. This area, as currently defined, has more oil than the remainder of the Texas-Louisiana area. The next most productive trend is the Pliocene trend of central Louisiana OCS which produced about 50% oil and 50% gas. Further to the west this producing trend dies out. The Miocene of western Louisiana is the third most productive trend producing mostly gas, and the Pleistocene of offshore western Louisiana ranks fourth.

The prospective horizons of the upper slope of offshore Texas should consist of a veneer of Miocene and Pliocene with intervals of Pleistocene. The Pleistocene sediments are considered the most prospective reservoir beds. The thickness of these deposits on the slope is variable but is at least 32-80 m.

The clastic sediments derived from the ancestral Mississippi River system have built out as deltaic deposits in the Gulf. The prospective sediments underlying the Texas-Louisiana shelf are those of Oligocene, Miocene, Pliocene and Pleistocene Age.

Figure A-5 The Rise and Fall of Sea Level Following the Wisconsin Glaciation (From R. W. Fairbridge, 1960)



Oligocene Sediments

The Frio Formation is the most prolific oil and gas producer in south Texas. About 90% of the hydrocarbon reserves in south Texas are found in this formation.

The prospective Frio section thickens seaward from a few hundred meters to more than 2000 m. Regional structural maps indicate that a drilling depth of 4920 or more will be required to test the prospective section in offshore south Texas areas.

Miocene Sediments

The Miocene trend is less prospective in Texas compared to offshore Louisiana. At the end of Oligocene time, the depocenters for continental-derived sediments shifted eastward, and the Mississippi River system brought to this rapidly subsiding area great quantities of sand, silt and shale. Much of this sediment was deposited in deltas and considerable amounts of clay and silt were carried by longshore currents to the innerdeltaic offshore area farther west. During early Miocene, the area of maximum sedimentation was located in southwest Louisiana but gradually shifted to southeast Louisiana, later Miocene. The Miocene section of southeast Louisiana is the thickest in the Gulf Coast Province. Small rivers (Rio Grande, Nueces, Colorado, Brazos, Trinity and Sabine) did transport a considerable amount of sediment to offshore Texas, but they did not construct deltas of the magnitude of the Mississippi Delta. The sands that reached the sea were distributed laterally by longshore currents and formed various islands by wave actions. The finer sediments were deposited in lagoons, bays, coastal marshes and in the neritic zone. The Colorado-Brazos River system did build several large deltas during Lower Miocene time when the area north of the Balcones fault zone in central Texas was uplifted and became an important source for sediments. The largest Colorado-Brazos delta is located shoreward of East Breaks Canyon (Western Gulf, Visual No. 4).

Pliocene Sediments

The Pliocene production in offshore Texas has been of little importance compared with that of Louisiana. Pliocene time was a period of uplift and erosion and the sediments that accumulated in the Gulf of Mexico or that were deposited in the coastal environment are, generally, seaward of the present shoreline. The area of maximum sedimentation in Pliocene time was located off the coast of southeast Louisiana. Much of Pliocene production is confined to the central and southeast Louisiana OCS area. Offshore Texas, two distinct provinces are indicated to exist in the Pliocene Trend. One province occurs in the Texas offshore area south of the San Marcos Arch. Sediments there are expected to contain sand derived from the Rio Grande River and associated rivers to the north. The other Pliocene province occurs in the eastern portion of the Texas offshore and continues into the East and West Cameron areas offshore Louisiana. This province is dominated by salt domes and deep-seated diapirs. The stratigraphic sections in offshore Texas, however, are much thinner than in offshore Louisiana, and exploratory results to date in this province have proved discouraging.

Pleistocene Sediments

Two Pleistocene provinces are indicated in the offshore Louisiana-Texas region. The first Pleistocene province occurs from the Ship Shoal area off Louisiana to the southern portion of the Galveston area offshore Texas. This province has a thick sequence of Pleistocene sediments with favorable stratigraphic conditions for both the generation and entrapment of hydrocarbons in porous rock, and structurally is characterized by salt domes and deeper-seated shale domes and ridges. The trend area, to the east (in West Cameron), is presently being developed as a gas producing province. Several fairly large gas fields have been found, some with associated condensate and oil reservoirs. Also, several wells are now being drilled in acreage offshore Texas High Island area which was leased in June 1973, East Texas Sale No. 34. The potential of this province is generally regarded as being very good.

The second province occurs offshore southwest Texas, and generally is made up of the Pleistocene offshore delta of the Rio Grande River. The Rio Grande built a subaqueous delta which prograded across the continental shelf and continental slope. The Pleistocene sediments are typified by a fairly sizable quantity of sand deposited under dominantly marine conditions, with interbedded deposits of continental sand material.

Climate

Surface Wind Patterns

The Azores-Bermuda atmospheric high pressure cell dominates the circulation over the Gulf, particularly during the spring and summer months. In late summer there is a general northward shift of the circulation and the Gulf comes under the more direct influence of the equatorial low pressure belt. During the relatively constant summer conditions, the southerly position of the Azores-Bermuda cell brings about predominance of south-easterly winds. The winds tend to become more southerly in the northern part of the Gulf. During the winter, winds usually blow from easterly directions with fewer southerlies but more northerlies. Winds from west and southwest are rare anytime during the year.

Sea surface currents in this area are generally weak and variable being largely determined by the winds. Wind driven currents are very complex with their velocities depending upon the speed, direction and duration of the wind as well as the orientation of the coastline and certain bottom characteristics.

Near the coast winds are more variable than over the open waters because the coastal winds fall more directly under the influence of the moving cyclonic storms that are characteristic of the continent.

Air Temperatures

Average temperatures at coastal locations vary with latitude and exposure. In winter they depend on the frequency and intensity of penetration by polar air masses from the north. These incursions, when they bring strong northerly winds, are called ‘‘northers‘‘ and may occur some 15 to 20 times between November through March.

Air temperatures over the open Gulf exhibit narrower limits of variation both on a daily and seasonal basis (Fig. B-1). In July, average temperature over the center of the Gulf is about 29° C and gradually increases coastward to within 3° C of temperatures recorded at coastal localities. East of Brownsville and Corpus Christi, Texas, January air temperatures over the open Gulf average about 18° C. The mean annual surface water temperature for the Gulf is 25° C (Leipper, 1954a).

Precipitation

Average annual precipitation along the Gulf coast increases from approximately 69 cm at Brownsville to over 102 cm at Galveston, and (137 cm) at New Orleans. Rainfall is fairly evenly distributed throughout the year, with the greatest amounts occurring during the months when the winds are predominantly out of the southeast and south, namely June, July and August.

Along the central Gulf precipitation is frequent and abundant throughout the year. At New Orleans, October is the only month with a precipitation average less than 8 centimeters. July, the wettest month, receives just under 18 cm. Stations along the entire coast record the highest precipitation values during the warmer months of the year. The month of maximum rainfall for most locations is July, however, at Brownsville the record maximum is in September. Winter rains are associated with the frequent passage of frontal systems through the area. Rainfalls are generally slow, steady and relatively continous, often lasting several days. Snowfalls are rare, and when frozen precipitation does occur it usually melts upon contact with the ground. Incidence of frozen precipitation decreases with distance offshore and rapidly reaches zero.

The warmer months usually have convective cloud systems which produce showers and thunderstorms; however, thunderstorms of this type rarely cause any damage or have attendant hail. Tornadoes and waterspouts are also rare in this area (Brower, et al., 1972).

Sky Cover and Visibility

Cloudiness

Along the Gulf coast cloudiness averages between 0.5 to 0.6 sky cover with relatively small seasonal variation. October is generally the clearest month and December through March the cloudiest. The Climatic Atlas of the U.S. (U.S. Dept. Commerce, 1968) shows that the central Gulf Coast received the highest percentage of possible sunshine in the summer and fall, ranging between sixty and seventy percent, with the high in October. The percentage of possible sunshine declines to a low in December and January (fifty percent or less) and increases gradually through the spring and early summer into the sixty percent range (Table B-1).

During the warm season, May through September, cumulus clouds begin developing over

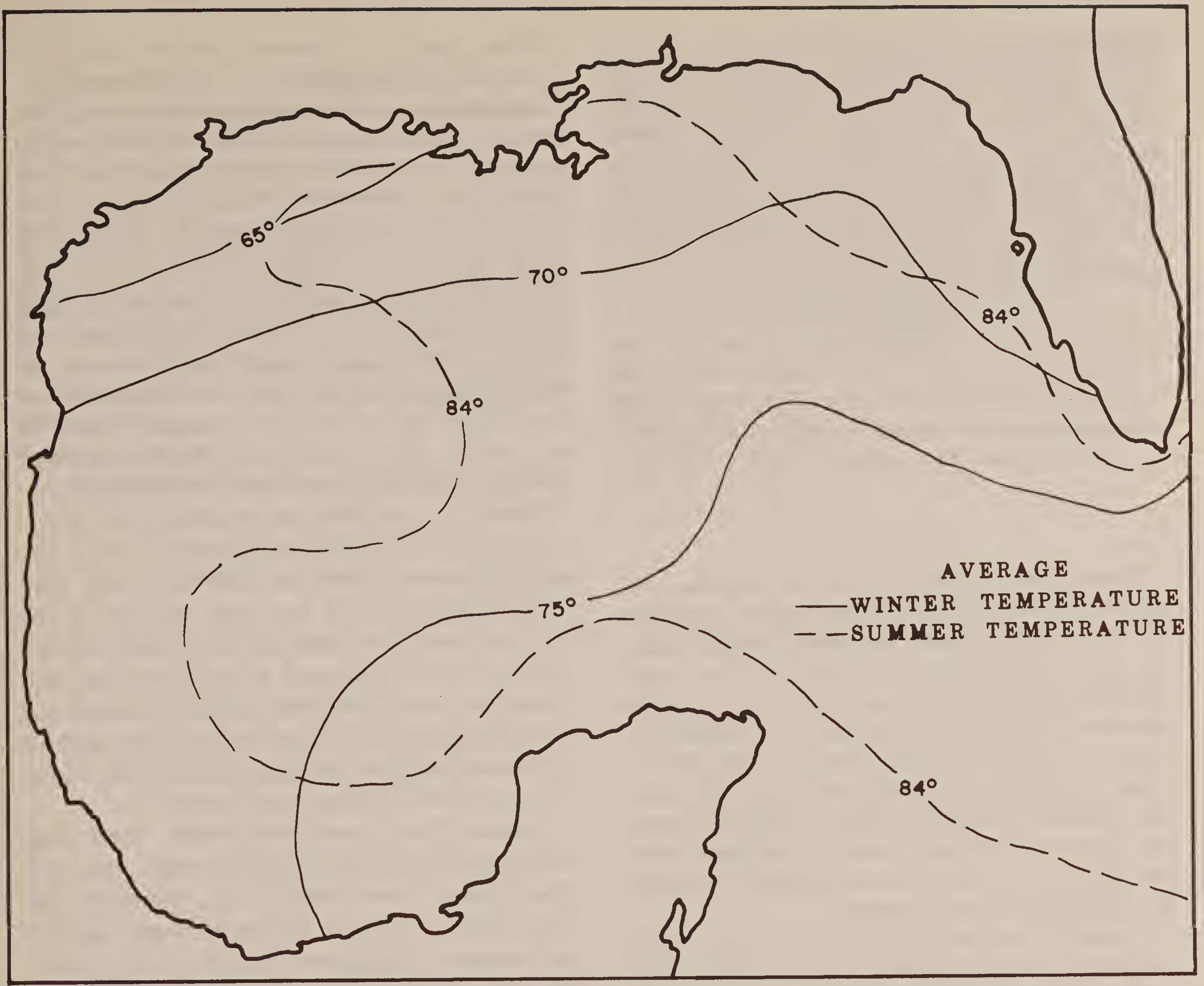


Figure B-1 Average summer and winter surface isotherms in °F for the Gulf of Mexico (Leipper, 1954a).

northern Gulf waters about 0300 hours and the larger clouds may produce scattered showers which dissipate when carried onshore during the morning by the sea breeze. Onshore cumulus development occurs during the day reaching maximum in late afternoon, often accompanied by rainfall (Orton, 1964). Much of the summer clouds are either convective cumuli or high, relatively transparent clouds (Brower, et al., 1972).

Table B–1.—*Percentage of possible sunshine*
New Orleans, La.

Jan	Feb	Mar	Apr	May	Jun	July
49	50	57	63	66	64	58
Aug	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**	
60	64	70	60	46	59	

Fog

Warm, moist Gulf air blowing slowly over chilled land or water surfaces brings about the formation of fog. From November through April, fog is encountered occasionally at points throughout the Gulf coast region. It is most frequent in the vicinity of harbor entrances and over land areas extending into the Gulf, such as Cape San Blas. Fog forms with southerly winds and dissipates during northerly winds. The heaviest occurrence of fog is usually in the early morning hours. It is generally at a maximum in winter with little heavy fog in summer.

Generally, coastal fogs last three or four hours although particularly dense sea fogs may persist for several days. Visibility offshore Louisiana is reduced to less than 5 km on a monthly average of four percent of the time. Poorest visibility conditions occur during winter and early spring when visibility is reduced to less than 5 km between 8 and 10 percent of the time (Peake and Muller, 1971).

Severe Storms

Tropical Cyclones

The largest and most destructive storms affecting the Gulf of Mexico and adjacent coastal zone are tropical cyclones. These have their origin over the warm tropical waters of the central Atlantic Ocean, Caribbean Sea or southeastern Gulf of Mexico. They occur most frequently between June and late October (Brower, et al., 1972) and there is a relatively high probability that tropical cyclones will cause damage in the Gulf of Mexico each year. Statistics for hurricanes and tropical cyclones are often lumped together since it is often difficult, especially in the older records, to determine the storm intensity while at sea. The probability of a tropical cyclone or hurricane influencing the north-central Gulf coast during any given year is one in six. Hurricanes vary considerably in intensity track patterns and behavior upon crossing land. McGowen, et al. (1970), explains that the storm approach is marked by rising tides and increased wind velocities; generally the longer a storm lingers in the Gulf, the larger the bulge of water it pushes ashore as it approaches land. These storm tides are commonly higher in the bays than on Gulf sea beaches, although flooding and pounding waves effect both areas.

There is no preferred approaching route of hurricane tracks although early season cyclones approach generally from the southeast while later ones are more out of the south. In spite of the fact that most hurricanes form in tropical ocean areas, a few are generated in the Gulf of Mexico. During the period 1901-1971, seven hurricanes and seven tropical storms formed in the Gulf north of 25° N and east of 85° W. See General Gulf, Visual No. 2 for 1954-1975 hurricane tracks.

Damage from hurricanes results from high winds and, particularly in the coastal areas, the storm surge or tide which is an abnormally high rise in the water level. Maximum surge height at any location is dependent on many factors including bottom topography, coastline configuration and storm intensity. The storm surge associated with "Betsy" in 1965 reached nearly six meters at Bayou Lafourche (U.S. Department of the Army, 1973); Hurricane Carla, in 1961, produced 7 m tides in Lavaca Bay, Texas. Hurricane "Camille" was the most severe hurricane in recent Gulf history, with top winds estimated at 324 km/hr, and barometric pressure in her calm eye as low as 68 cm of mercury.

The flood tides and high waves carry shells and sediment from deeper offshore areas onto seaward beaches, spreading a veneer of deposits over the broad, flat hurricane beaches. In the marsh areas extensive and prolonged inundation and ponding occurs, resulting in damage or loss to habitat and man-made structures. The storm surge flood may also produce breaches or channels in natural barrier islands or in levees.

In addition to the tropical cyclones, extratropical cyclones that may vary greatly in intensity occur in this area primarily during the winter months. These storms have attained wind speeds as great as 55 to 93 km/hr. They originate in middle and high latitudes forming on the fronts that separate different air masses. The Gulf of Mexico is an area of cyclone development during the cooler months due to the contrast in temperatures of the warm air over Gulf waters and the cold continental air over the United States. These storms rapidly dissipate, or move on, after going out over the Gulf of Mexico.

Polar Outbreaks

A phenomenon known as ''norther'' is quite common in the area in question during the winter months. A norther occurs when cold, polar air moves southward from the cold interior of the North American continent out over the warm waters of the Gulf. This unstable cold air mass, when heated from below, develops strong gusty northerly winds with considerable cloudiness and showers. During a typical winter as many as 30 such cold outbreaks reach the Gulf Coast. The majority of these cold outbreaks, spilling out over the Gulf, produce winds in the 28-37 km/hr range but approximately one-third of these cold outbreaks have winds over 62 km/hr with approximately half of these being vigorous enough to reach 89 km/hr, (U.S. Dept. of Comm., 1967).

Physical Oceanography

Circulation

Loop Current

Circulation in the Gulf of Mexico is dominated by the "Loop Current" which is the strongest during the late summer through winter. Circulation of warm Caribbean waters can extend as far north as the Mississippi Delta (Fig. C-1). Eddy currents off the major loop probably account for nothern growths of coral such as the Florida Middle Grounds offshore Florida and the Flower Garden reefs offshore Texas. Current trajectories in the Gulf have been mapped for many years by the Naval Oceanographic Office (1955). The Surface Current Wind Roses shown in Western, Central, and Eastern Gulf, Visual No. 6, are from a compilation of Naval Oceanographic Office Data. Additional Loop Current data are contained in: USDI (1975c), Eleuterius (1974) and Sweet (1974). These studies show that water movements in the Gulf of Mexico are controlled by a variety of interacting forces including fresh water inflow from land, currents set up by winds, currents and water transport induced by surface gravity waves, tidal currents, currents associated with internal waves and movement of water masses due to density differences.

The general circulation pattern for the eastern Gulf consists of a clock-wise Loop Current flowing in through the Yucatan Strait and out through the Florida Strait (Fig. C-2). This is essentially an extension of the Yucatan Current which flows into the Gulf, circles to the right and flows out through the Florida Strait to join the Gulf Stream Current. The western half of the Gulf has no strong, semi-permanent currents but is characterized by a well-defined pattern of winter flow and a highly variable summer pattern (Nowlin, 1971). There is a general westward sweep of currents along the northern shelf west of the Mississippi Delta. Another mass of water moves northward along the Mexican coast to a zone of convergence off Texas. All the currents in the western Gulf seem to flow toward this general zone.

Surface circulation

Figure C-3 depicts surface circulation trends along the Louisiana coast, emphasizing the general westward movement of currents. The nearshore regime in this area is influenced by several factors, among them winds, tides, offshore current flow and fresh water discharge from coastal rivers. In most areas significant winds are the major control of surface currents.

Currents around the Mississippi Delta are strongly influenced by the fresh water outflow from the river. At Head-of-Passes the Mississippi River branches into three major channels: Pass-A-Loutre, transporting 37% of the total river discharge; South Pass, 29% and Southwest Pass, 15%. Fresh water discharge rates vary seasonally with highest values occurring during the spring and lowest in the fall. Outflow from the Mississippi Delta maintains its general integrity as it passes over the more dense, saline underlayer. Scruton (1956) observed a fresh water plume extending 20 m off Pass-A-Loutre. This has been confirmed by Eleuterius (1974) whose data indicates that at times this plume extends some forty miles eastward. Fresh water plumes to the south and west are less well known, however, they undoubtedly exert considerable influence.

After sweeping westward along the Louisiana continental shelf prevailing surface currents turn southwestward, roughly paralleling the Texas coast. Another surface current system moves northward along the Mexican coast to a zone of convergency off Texas. The actual area in which the north and south moving currents converge changes throughout the year in response to atmospheric conditions. In winter the area is to the south of the United States-Mexican border. The area shifts gradually northward during the spring and summer months. Current velocities range in speed from about 0.7 to 2.8 km/hr.

Bottom circulation

Little is known about bottom circulation in the Gulf of Mexico. Bottom current measurements although feasible are so rare that circulation patterns can not be described. Reports from divers indicate that bottom currents can be strong enough to make diving hazardous and mobility in some areas difficult.

Sea Surface Temperatures

According to Leipper (1959a), the main feature of the average winter sea surface temperature for the Gulf of Mexico is a gradual drop from approximately 24° C in the south to 18° C in the north in all parts of the Gulf. In the summertime, average temperatures are very nearly uniform at 29° C throughout the Gulf. Years of investigations

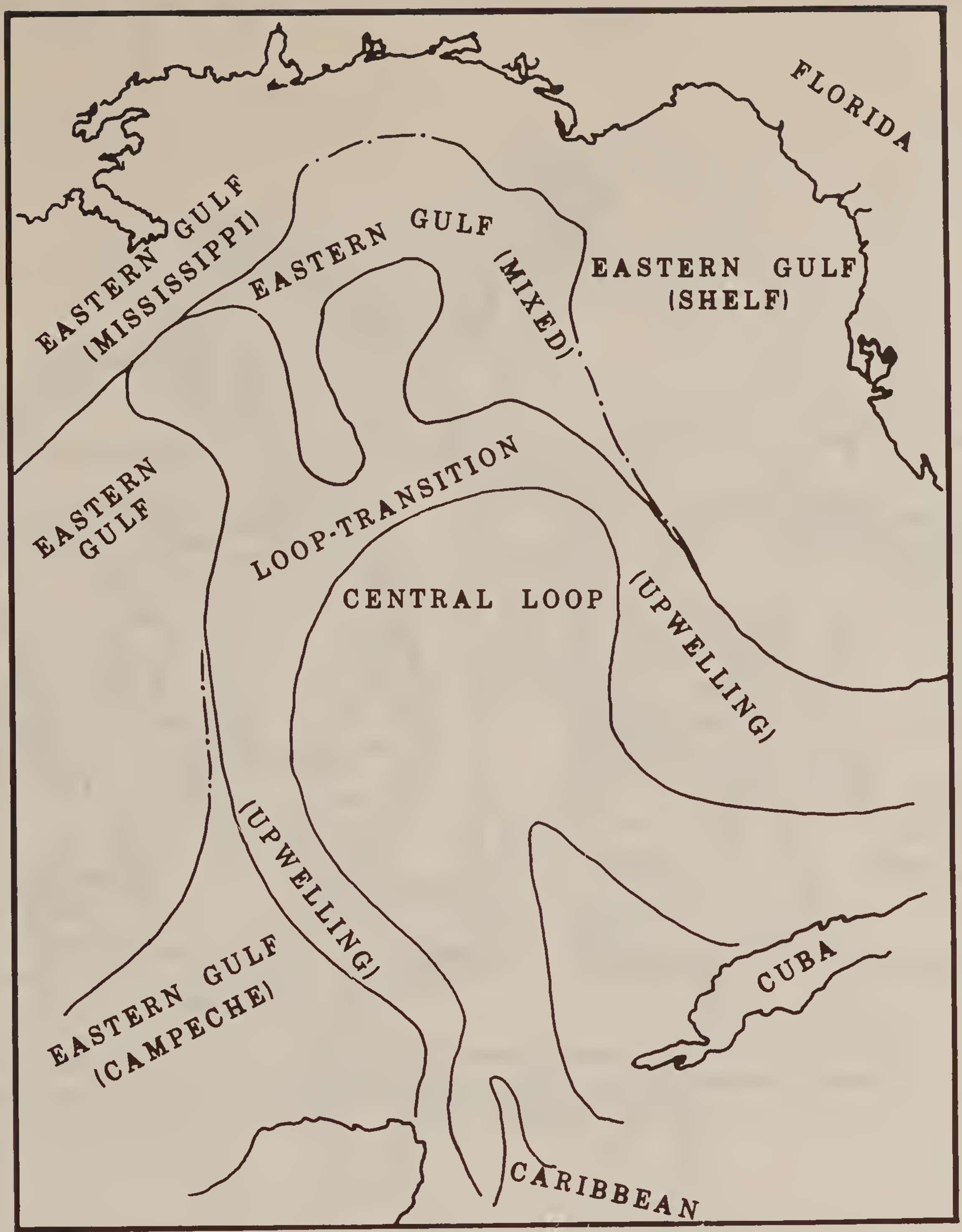


Figure C-1 Water Masses in the Eastern Gulf of Mexico During May 1970 (From Austin, 1971).

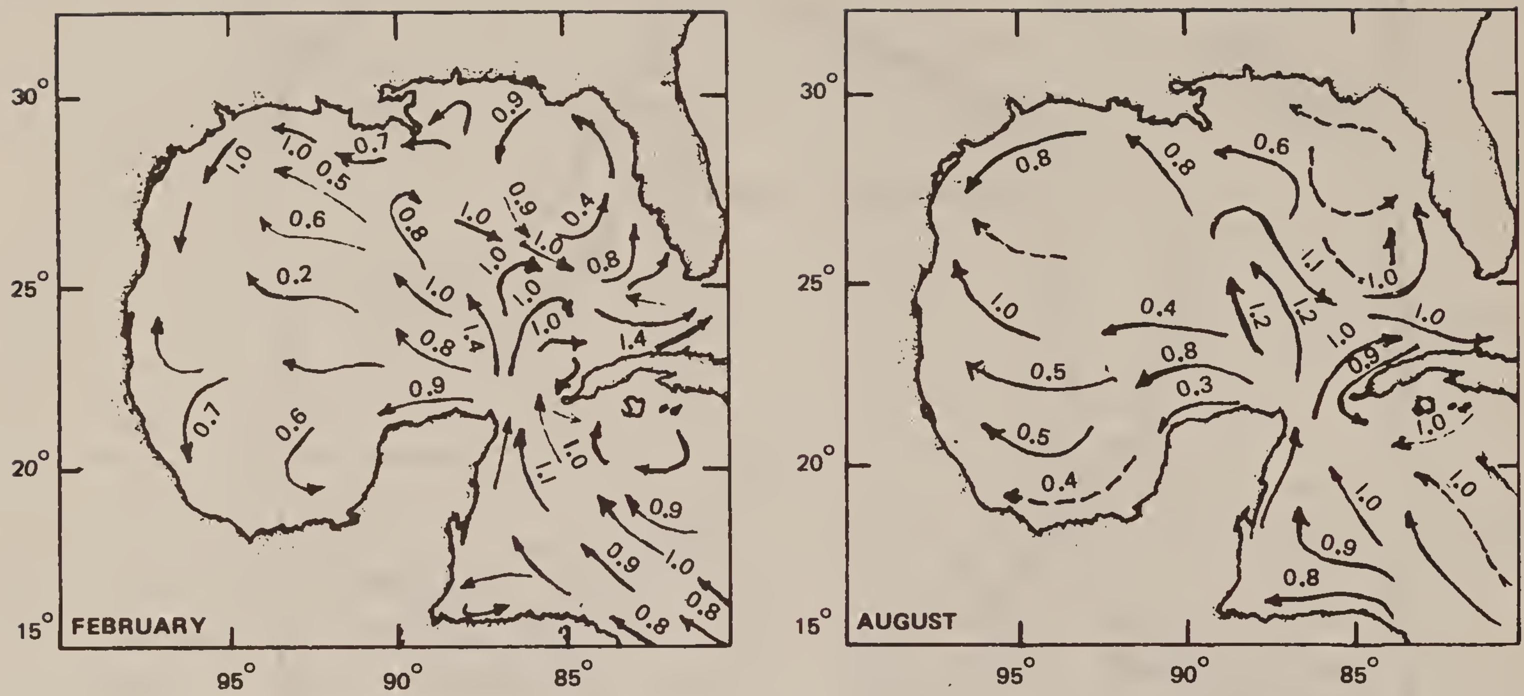


Figure C-2 Estimated Average Speed (Knots) of Surface Currents in the Gulf of Mexico from U. S. Naval Oceanographic Office Pilot Charts for February and August (After Nowlin, 1971)

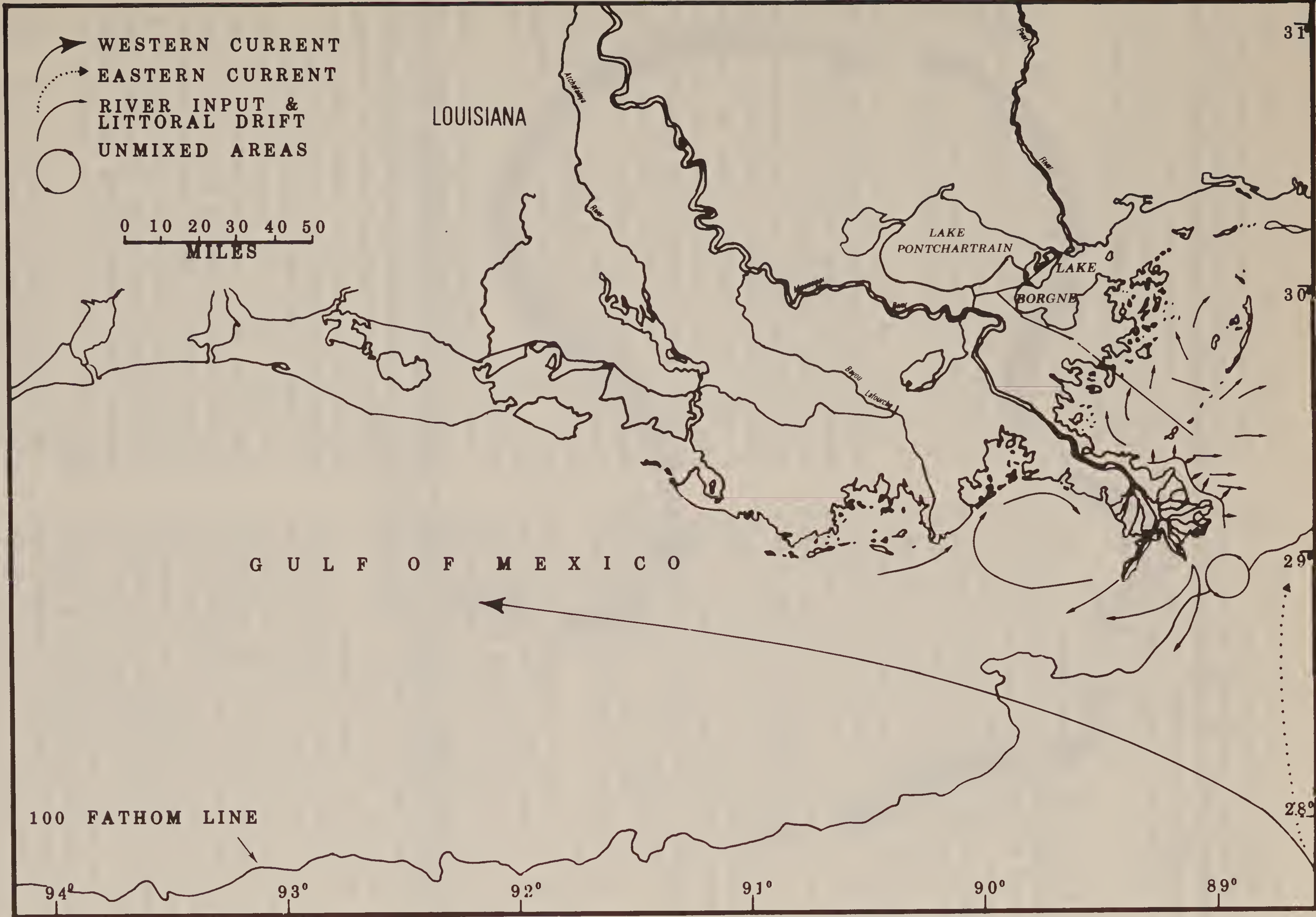


Figure C-3 Generalized surface circulation along the Louisiana continental shelf (from Stone, 1972).

have shown that considerable deviation from these average isotherms may occur at certain times. In shallow coastal waters and in estuarine and marsh areas, water temperatures approximate air temperatures, but without reaching the extremes exhibited by air temperatures on the short term.

Tides

The tides of the Gulf of Mexico are weakly developed and usually their observed range does not exceed 0.7 meters (Durham and Reid, 1967). Semidiurnal (twice daily) tides are small, and therefore, overall tides in the Gulf are considered diurnal (daily) in character. In 1897, R. A. Harris (Grace, 1932) suggested that the diurnal tides of the Atlantic Ocean influences the tides in the Gulf through the Yucatan Channel. Later in 1900, he expressed the opinion that a single oscillating system with a nodal line extending from western Haiti to Nicaragua is formed by the Gulf of Mexico and the Caribbean Sea. This would cause the tides of the Gulf to be simultaneous. In 1908, Enros (Grace, 1932) arrived at a similar conclusion considering the Gulf and the Caribbean Sea to be a single oscillating body with a period of nearly 24 hours. Tidal regimes have been shown for the Gulf of Mexico as displayed by Eleuterius (1974) in Figure C-4.

In 1908, C. Wegmann (Defaunt, 1961), considered the resonance effect of the diurnal components of the Gulf and found the period of free oscillation for an east-west oscillation to be 24.8 hours. According to Grace (1932) the diurnal tide enters through the Florida Straits, progresses counterclockwise around the basin, is reflected by the northwestern and southern coasts and egresses through the Yucatan Channel.

When the moon is near its maximum declination, the tide is diurnal and has the greatest range. When the moon is over the equator, the tide has the least range and there may be several days having two highs and two lows. Although tides in the Gulf have a small range they do have important roles in modifying currents and accelerating the movement of water through narrow passages.

Spring tides are slightly higher, but since the range is so small, meteorological effects can completely mask tidal fluctuations (U.S. Dept. of Commerce, 1967). For instance, an onshore wind can pile-up water against the coast to a height of 1.2 meters above mean sea level. Tides are diurnal (one high and one low per day), with maximum ranges recurring about every two weeks (Stone, 1972). Highest mean water level occurs during the period December through March.

Tidal currents do have some small effect on flushing rates in enclosed bays, but because tidal ranges are small, currents resulting from tides are also small.

Sea, Wind, Waves and Swell

The coastaline of the region of the proposed sale is characterized as a low energy area in terms of wave power (Stone, 1972). The annual average wave height is 0.9 m (Brower, et al., 1972), with 75% of all waves being smaller in height than 1.5 m.

Direction and height of waves at an offshore station closely correlates with wind direction and intensity. On an annual basis waves come out of the northeast, east, southeast and south 70.9% of the time (Stone, 1972). July and September data reflect the strong influence of the southerly winds resulting from circulation around the Bermuda High. The shift to more northerly and northeasterly wave origin accompanies the change in wind direction in winter when it is dominated by continental air masses and ''northers''. From May to August 80 to 90% were 1.5 to 2.4 m in height, and less than one percent exceeded 3.7 m in height. Waves from the northeast and southwest tend to have greater heights than those from other directions.

Stone (1972) reported that wave power along the coast is less during spring and summer and greater during autumn and winter by a factor of 2 or 3. He further states that the Mississippi and Atchafalaya (off Vermilion) deltas are advancing and the Barataria and Terrebonne coastlines are retreating. In the latter case, the rate of retreat is 7 to 15 m/yr, in the former case it is 3 to 7 m/yr.

The wind velocity, the distance over which the winds blows (fetch), and the length of time that the wind blows (duration) all have a direct effect on wave growth. In general, any increase in one of these factors will result in larger waves. Sea is a term applied where waves are actively being generated. Swell refers to long period uniform waves some distance from the generating influence.

The average height of waves in the Gulf average from 0.9 to 1.2 meters. Higher wave heights occur during the period of November

FIGURE C-4 GULF OF MEXICO TIDAL REGIMES. From Eleuterius, C. K. 1974. Mississippi Superport Study, Environmental Assessment.

through March when strong northerly winds prevail.

Prevailing winds during spring, summer and early fall are from the southeast and wave heights are generally less during this period. Waves associated with storms range considerably higher. During hurricane ''Camille'' in 1969, for example, waves 21 m high were reported offshore, with winds exceeding 322 km/hr.

Due to the coriolis effect sea breezes rotate clockwise in the northern hemisphere during a 24 hour period. Usually the sea breeze will start around 1000 hours, reach a maximum at 1400 hours and afterwards be replaced by the nocturnal land breezes. To answer questions on amplitude phase and frequency of responding waves, currents and beach erosion and deposition, a fully instrumented project was undertaken on Santa Rosa Island, Florida, by Sonu, et al. (1973). Their results demonstrated that sea breeze significantly affected the dynamic processes operating on the coast in the following summary:

(1) Meteorological parameters such as aerodynamic roughness, shear stress and atmospheric stability exhibited definite coupling with the wind speed. A new relationship between the friction velocity and the wind speed at 10 meters was found; this new relationship contrasts with conventional deepwater expressions. The aerodynamic roughness depended not only on waves, as was expected, but also on atmospheric stability mainly associated with land breeze.

(2) The sea breeze produced a high-frequency peak in the nearshore wave spectrum that dominated the background swell in the afternoon and evening. The response of the wind waves involved amplitude, frequency and direction, whereas that of the swell was primarily limited to amplitude.

(3) Nearshore currents responded with a lag of 3-5 hours to the onset of the sea breeze cycle with current amplitudes of up to 25 cm/sec. As a consequence of the proximity of the coast and the surface slope associated with wind setup, these currents flowed essentially parallel to the shoreline and had only minor onshore-offshore components.

(4) Wave-induced currents around and inside the inner bar underwent systematic diurnal variations in response to offshore wave breaking and incident angles of the diurnal wave field, changing from closed circulations (early afternoon), to meandering currents (late afternoon), to weakly curved parallel currents (night and early morning).

(5) The beach system acted as a low-pass filter to input waves, so that both swash and groundwater fluctuations underwent high-frequency attenuation. The cutoff frequency varied as a function of the combined effects of the tide and diurnal wave field.

(6) Topographic response exhibited dependence on the scale of topography and excitation frequency. Whereas small-scale features such as ripples, megaripples, and beach cusps changed within a hourly or shorter time scale, large features such as crescentic bars and rhythmic shorelines on the order of 120 meters in wavelength remained unresponsive for over three weeks.

Chemical Oceanography

Nutrients

In the marine ecosystem phytoplankton constitute the primary producers and as such are dependent on an adequate supply of three essential nutrients: nitrogen, phosphorous and silica. The primary sources of supply of these nutrients are upwelling of deep waters, advection and discharge from land sources (rivers and industrial and domestic sewerage). The primary process depleting the concentration of nutrients in the surface is rapid uptake by phytoplankton and consequent removal of the phytoplankton by predation or by sinking. As a result, only low concentrations of nutrients are normally found in surface waters except in local source areas.

Major source areas of turbidities are the rivers and bay outlets into the Gulf of Mexico, principally the Mississippi and Rio Grande rivers. Organic content of the waters are high bordering south Louisiana and Texas. Fanning (1974) rejects upwelling as the cause of the bottom enrichment and favors this enrichment from release of the nutrients from bottom sediments through diffusion or seepage. Manheim (1974) points out that the intermediate and surface nutrient values could be caused by uptake by benthic algae.

Salinity

The salinity patterns of the Gulf of Mexico (Fig. D-1) are principally determined by: inflow of ocean waters through the Yucatan Strait, precipitation and inflow of fresh water from land sources, evaporation, circulation and mixing and outflow through the Straits of Florida. In the northern Gulf runoff from the Mississippi, Atchafalaya and from smaller rivers to the east and west gives rise to a band of low-salinity water (Nolan, 1972).

In the upper 50 m, water in the central Gulf of Mexico typically has a salinity of very near 36.0 parts per thousand (Leipper, 1954b). The distribution of surface salinities in the winter is generally lower. A similar distribution pattern, but with generally higher salinities because of high evaporation rates, is found for summer conditions. In the eastern Gulf these distributions are modified by the seasonally dependent Loop Current (Sackett, 1972).

Trace Metals

The trace metals that usually occur in the marine environment include cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, iron, uranium and zinc. These occur in concentrations normally less than one part per million (1 ppm.). These metals can enter the marine environment through weathering of rocks or by pollution discharge of human development.

Analysis of sediments to determine concentrations of heavy metals were made by the U.S. Geological Survey for the South Texas OCS (Berryhill, 1975). The following conclusions have been drawn from this study.

As a regional pattern, the trace metals content of sediments in estuaries adjacent to the continental shelf are relatively higher than in the sediments of the OCS.

Compared to the average trace metals content for the south Texas OCS as a whole, only cadmium and manganese are significantly high. For several trace metals, including cadmium, the highest concentrations are in the area of suspected gas seeps along the outer edge of the shelf in the northeastern part of the OCS.

The suspected gas seeps appear to be emanating upward along fault planes and may be depositing trace metals in the sea floor sediments, thus explaining the higher concentrations of some trace metals there.

In the south Texas OCS, the average levels for all trace metals determined are lower than the average levels for the segment of the northwestern Gulf shelf immediately to the north. For the overall northern Gulf of Mexico continental shelf, the average levels within the south Texas OCS are comparable.

Knowledge of trace metals concentrations in sediments of other continental shelves of the United States is too scant to permit comparison with the shelf off south Texas

A most intensive study of trace metals in the Gulf was completed by Corcoran (1972) for six trace metals: Cd, Pb, Cu, Cr, Zn and Mg. Except for copper, the concentration of the five other metals was ten times the concentration typically observed in open ocean waters. Also, manganese was higher than concentrations reported by Rona, et al. (1962). This seems to indicate enrichment of trace metals by the Mississippi River and from Escambia and Perdido bays.

Figure **D·1** *Surface salinities (parts per mil),* Hidalgo *62-H-3.*

When adequately sampled it appears that trace metal data can complement or reinforce circulation information and can indicate dynamic characteristics. Evidence of this is discussed in A Summary of Knowledge of the Eastern Gulf of Mexico (Jones et al., 1973) as follows:

An examination of the distribution of trace metals in the ESCAROSA (Escambia-Santa Rosa counties) area indicates that water movements are complex. There seems to be a general movement of surface waters from east to west. Salinity, silicate and manganese data indicate a surface flow of water out of the bays, yet the trace metal data show an offshore enrichment with no apparent surface connection. This would indicate that the trace metals are carried below the surface upon their entrance into the Gulf, only to rise again a few miles away in small divergent areas, or they are entrapped within the bays and their offshore enrichment comes from the Mobile Bay and Mississippi River sources, or the surface waters are enriched by wind-carried aerosols. Possibly all three processes contribute. Sediment studies seem to indicate bay entrapment, but it is also well known that trace metals are released from sedimentary particles upon contact with saline water, and it is also well known that trace metals (especially lead) are constituents of the aerosols.

Slowey and Hood (1969) have reported high trace metal content at intermediate depths in Gulf water. They found this metal content at intermediate depths to decrease as the water moved through the Gulf of Mexico and concluded the metal origin to be from outside the Gulf, either from residual subantarctic intermediate water, or from continual rain of decaying organisms with their resultant release of metals during the northward transit of the water. The outside origin of high metal content of intermediate water seems reasonable and feasible. However, the conclusion is based on the resemblance of copper, manganese and zinc distributions in the Gulf to these found at one station taken from Cuba.

A map of trace metals for the Gulf of Mexico sediments has been proposed by Holmes (1973) from a semiquantitative analysis of sediment samples taken mainly from NMFS Geronimo cruises. Holmes (1971) has prepared a detail map of zirconium distribution in the northwestern Gulf from Galveston to beyond the Flower Garden Banks, Figure D-2. His analyses indicate that the highest trace-element concentrations are in regions of the shelf that are actively receiving sediments. The zirconium concentrations are an exception because they are deposited in areas of slow deposition along the elongate bathymetric features in offshore Texas. This correlation of zirconium concentration to the elongated features suggests that the topographic features are ancient shorelines that have been submerged during the past Pleistocene rise in sea level.

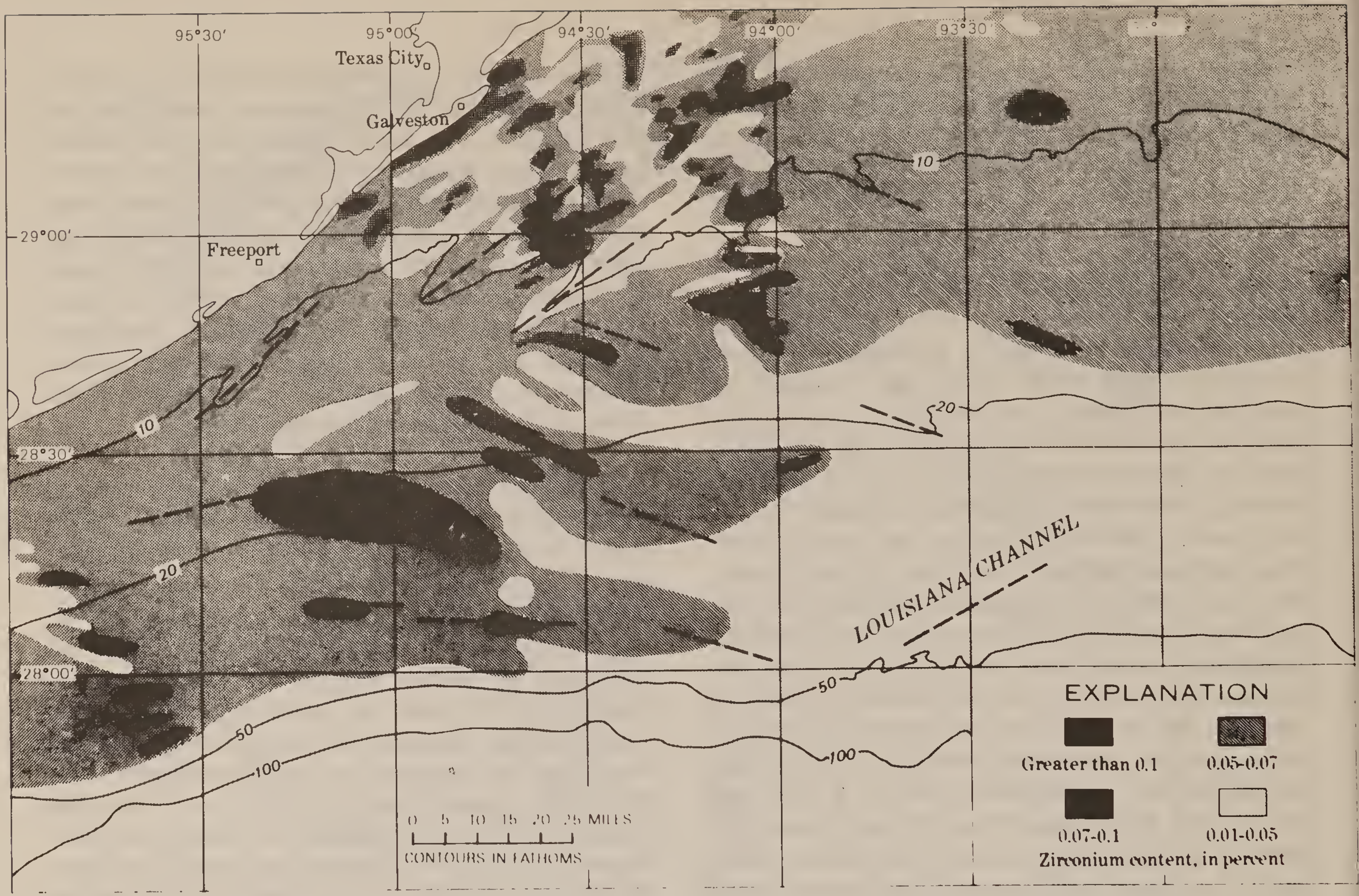


Figure D-2 Distribution of zirconium in the central part of the northwest Gulf of Mexico shelf. Dashed lines approximate the axes of the topographic ridges

Biological Oceanography

Considerable data is available concerning the biology of the Gulf of Mexico. Previous environmental statements prepared by the Bureau of Land Management have treated this subject in detail. Reference to the following environmental statements are suggested for a more detailed discussion on the biology of the offshore environment for this proposed sale area.

Louisiana—Final Environmental Statement, Vol. 1, OCS Sale No. 36, pp. 199-226.

Texas—Final Environmental Statement Vol. 1, OCS Sale No. 38, pp. 176-196.

Gulf of Mexico—Final Environmental Statement—Programmatic, pp. 328-351.

Gulf of Mexico—Final Environmental Statement—Vol. 1, OCS Sale No. 41.

Plankton

Zooplankton

According to Bogorov, et al. (1968) the distribution of zooplankton for the Gulf of Mexico is 51-200 mg/cu. m. In addition, Khromov (1965) studied the quantitative distribution of zooplankton biomass in the northwest Caribbean Sea and most of the Gulf of Mexico, and indicated a zone of low zooplankton density (0.5g/cu.m) east of Galveston; southwest of Galveston the nearshore density exceeded 0.5g/cu.m in the shallow coastal waters with lower densities seaward.

The most important grazers are the copepod crustaceans, which are the most abundant zooplanktonic group in any given plankton sample (Raymont, 1963). Where phytoplankton populations become abundant, copepod populations will also flourish.

Common copepod species found in neritic Gulf waters include the calanoid copepods *Euchaeta marina*, *Neocalanus gracilis*, *Scolecithrix dana*, *Candacea pachydactyla*, *Unidinula vulgaris*, *Eucalanus attenuata* and *Acartia tonsa*, as well as the cyclopis copepods *Copilia mirabilis* and *Corycaeus* spp. Euchaeta and Corycaeus differ from the rest in being carnivorous. *Acartia tonsa* is a dominant nearshore form in bays and estuaries of Texas and Louisiana, and is found less commonly offshore (Gillespie, 1971).

Euphausiid crustaceans are also prominent members of the zooplankton assemblage. Major species found in the Gulf are *Euphausia americana*, *E. mutica*, *E. brevis* and *Stylocheiron carinatum*. Feeding habits of euphausiids have variously been described as herbivorous, carnivorous and detritivorous.

Possibly the most significant carnivores in the zooplankton are the chaetognaths (arrow worms). Copepods dominate their diet but this may be an artifact based on relatively high copepod abundance (Raymont, 1963). They also feed on fish and barnacle larvae. The genus *Sagitta* is common worldwide; Gulf species include *S. setosa*, *Pterosagitta sp.*, *Krohnitta sp.* and *Eukrohina sp.*

Other common carnivores in the zooplankton include the ctenophores (*Pleurobrachia* and *Beroe*), medusae of various species, ostracods, cladocerans (*Podon* and *Evadne*), mysid and amphipod crustaceans, heteropods, (*Atlanta leseuri*), pterpods, salps and pyrosomes. Another significant group of carnivores are the various larval and immature forms, both holoplanktonic and meroplanktonic organisms. These include most of the crustaceans mentioned, the tunicates, echinoderms, cephalopods, ectoprocts, sponges, annelid and nemertean worms. Fisheries larvae are important carnivores, and the survival of larvae of commercial fish has an obvious economic impact.

James, et al. (1972) extrapolated from the taxonomic studies of the eastern Gulf and the few Texas zooplankton collections which have been examined, and concluded that Texas shelf waters are quite rich in the same zooplankton species found elsewhere in the Gulf, with representatives from many diverse biotic groups.

Phytoplankton

El-Sayed (1972) used measurements of *chlorophyll a* (a bluish black pigment found in phytoplankton) to calculate estimates of the phytoplankton standing crop (total number or weight of living organisms momentarily present in an environmental unit, Pennak, 1964) for the Gulf of Mexico. Surface *chlorophyll a* showed higher concentrations (high standing crop) during the winter than at any other season; these were followed by a decrease in the standing crop of phytoplankton during spring, and a gradual increase in summer and fall. In terms of *chlorophyll a* (sea-surface values and data integrated for the euphotic zone), the Gulf of Mexico is no different from other tropical or sub-tropical bodies.

The levels of gross primary production (total quantity of green plant protoplasm produced per unit time in a specific habitat) in different geographic localities in the Gulf of Mexico resemble

the distribution of the phytoplankton standing crop. As with *chlorophyll a*, the surface and integrated (with the euphotic zone) primary productivity values in the inshore water (0.55mg C/cu.m/hr and 7.04mg C/sq.m/hr respectively) were higher than those values for offshore waters (0.21mg C/cu.m/hr and 5.45mg C/sq.m/hr). The average primary productivity of the Gulf was 0.15g C/sq.m/day (El-Sayed, 1972).

The open Gulf phytoplankton assemblage includes the diatom genera *Gossleriella*, *Ethmodiscus* and *Planktoniella*, and the dinoflagellate genera *Teiposolenia*, *Heterodinium*, *Amphisolenia*, *Murrayella*, *Histioneis*, *Ptychodiscus*, *Cladopyxis*, *Kofoidinium*, certain *Ceratium* spp. and *Pyrocystis*, according to Steidinger (1973). While the dinoflagellates are more diverse in this area, they do not necessarily dominate the standing crop.

Graphic representation of the Gulf of Mexico phytoplankton production (mg C/sq.m/d) benthic algae and seagrasses may be found under general Gulf, Visual No.3.

Benthos

The benthic communities for the OCS can be broadly described as shallow, intermediate and deep shelf assemblages, and slope assemblages. Within these broad areas, more specific assemblages can be described for shrimp grounds, oyster grounds, sand bottoms, silt and mud bottoms, rocky bottoms and hard banks. For location of these bottom types see the following visual graphics: Bottom sediments—western and central Gulf, Visual No. 4; undersea features—western and central Gulf, Visual No. 4; Coastal zone and offshore fisheries—western and central Gulf, Visual No. 5; Migration of Gulf of Mexico penaeid shrimp and main fishing grounds—general Gulf, Visual No. 5.

The organisms are generally distinct for each of the three neritic zones (supratidal or supralittoral; intertidal or littoral, and subtidal or sublittoral), but specific species may be found in more than one zone. Zonation is characterized more by dominant species than by distinct assemblages of numerous species.

The main benthic floral groups are the seagrasses and the benthic algae, (General Gulf Visual No. 3). The seagrasses have been discussed previously, and their outer limits define the inner limit of the offshore environment for this report. The benthic algâe predominantly inhabit rocky coastlines and hard bottom. The capacity of such habitats in the Gulf of Mexico area allows the seagrasses to dominate the benthic algae. Representatives of the four major phyla of algae (cyanophyta, blue-green; Rhodophyta, red; Phaeophyta, brown; Chlorophyta, green) may be found in suitable locations, but in offshore waters, red and brown algae predominate (Odum, 1971). In exceptionally clear waters, benthic algae are known to grow in at least 183 meters of water, especially coralline red algae, and apparently green, brown, and non-coralline red algae as well (Humm, 1973). Locally, in depths of 18-91 meters there may be extensive bottom cover of algal nodules, fist-sized and larger spheroidal aggregations or coralline algae and carbonate debris (Logan, 1969).

The epifaunal representatives offshore Louisiana and Texas include almost all animal phyla. They range from the sessile organisms like sponges and anemones to the slower moving forms such as shrimp and crabs to the highly motile demersal fish. Demersal fish include the commercially important species such as: flounders, red snapper, croakers, groupers, etc...

The most important commercial epifaunal species for the Gulf of Mexico are the brown shrimp, (*Penaeus aztecus*), the white shrimp (*Penaeus setiferus*), sea bob (*Xiphopeneus kroyeri*) and the royal red shrimp (*Hymenopenaeus robustus*). Royal red shrimp are found in deep waters from 175 to 300 fathoms.

Texas and Louisiana Shelf

Parker (1960) conducted a detailed study of the benthic communities off the Texas and Louisiana coast. He divided the offshore communities into the following habitats: surf zone or sandy beaches; inner shelf, 4 to 23 meters, intermediate shelf, 24 to 65 meters; outer shelf, 69 to 120 meters; the upper continental slope, 125 to 1200 meters and the calcareous bank community and speciated organisms for each assemblage for sediment type. Assemblage living within silty clays in the intermediate shelf community are completely different in composition from those on sandbottom at the same depth. Certain species do bridge the two sediment types to create larger associations. Studies of the continental shelf in other parts of the world and in all oceans proved the same basic assemblages listed for Louisiana and Texas occupy similar depths in the same latitudes (Parker, 1960).

Nekton

Nekton for the offshore waters are represented by five major taxonomic categories—marine mammals and reptiles, the fishes, the cephalopod molluscs (octopuses and squid) and certain crustaceans (shrimp and swimming crabs), (General Gulf, Visual Nos. 4 and 5). Individuals of this group commonly but not always, range over broad areas, thus participating in several biotic communities. However, most nekton is limited in geographic and vertical ranges by the same environmental conditions as less mobile organisms, i.e., temperature, salinity, available food, and types of bottom.

The nekton component of the environment can be divided into strictly open water nekton, and nekton which spend some portion of their lives in nearshore, estuarine, or marsh waters. Many of the finfish of commercial and sportfishing importance are strictly offshore residents, such as the red snapper, various groupers, sailfish, and marlin. Of particular importance from commercial and sport fishing standpoints are the semi-catadromous species which spawn in open water, move inshore to bays and estuaries for their juvenile life stage and return to deeper waters as adults.

The majority of biologists who have worked in the northern Gulf of Mexico have called attention to the presence of mainly warm-temperate or subtropic assemblages rather than tropical or Caribbean biota. The fauna is comparatively rich and includes many species that are found nowhere else, yet less is known about it than that of any other coastal section of the United States.

Knowledge on shelf and offshore fisheries for the western and central Gulf has been mainly limited to check lists, identification keys, and distributional studies. James, et al. (1972) stated that very little is known about the ecological relations of most fish species of the shelf, especially those which live beyond the inner shelf. The inner shelf area is defined by Parker (1960) as that region between 4 to 23 meters water depth, intermediate 24-65 m and outer 66 to 120 m. Data presented by Hildebrand (1954) and Moore, et al. (1970) on fish faunas of the inner and intermediate shelf showed catches on the inner shelf to be less abundant and less diverse than those on the intermediate shelf. Hildebrand (1954) recorded only 80 fish species from the inner shelf whereas 122 species are recorded for the intermediate zone.

Members of the nektic assemblage ranging over broad areas of the pelagic environment include squid and the schooling fishes, such as the amberjack, crevalle jack, horse-eye Jack, bluefish, king mackerel, various anchovies and herrings, and menhaden. Several types of pelagic fishes do not travel in schools, but rather roam alone or in small groups. These types include the cartilaginous fish, the sharks, and the bony fish, such as Atlantic sailfish, and blue marlin.

Certain oceanic fish visit the shelf waters during the summer months. These include the mackerels, bonito, amberjack, blue runner, dolphin and a number of billfishes and other species of sport and commercial interest. These wide-ranging, fast-swimming predatory fishes are often caught within sight of shore, especially around the mouth of passes where they feed on anchovies, silversides, squid, shrimp, and bottom fishes.

Data by James, et al. (1972) from fish collections on the continental shelf of Texas in 1971 suggested a greater species diversity for the inner shelf and greater abundance on the outer shelf, with the intermediate shelf being intermediate in fish diversity and abundance, (Table E-1) or a greater abundance is found closer to shore and the species diversity increases as one moves into deeper waters. Catches on the inner shelf are seasonally quite variable and tend to be dominated by species which utilize the estuarine habitat in part of their life histories.

The fish fauna of the northeastern Gulf is richer due mainly to the presence of a number of eurythermic tropical species. It has been suggested (Briggs, 1958) that this contrast in species diversity may be caused primarily by presence of different benthic communities.

In the northern Gulf, there is also some indication of speciation with certain warm-temperate genera. For example, one species of Menhaden, *Brevoortia gunteri*, is found in the western Gulf while another, *B. smithi*, exists in the eastern part (Dahlberg, 1970). Similar patterns have been found in the blenniid genus *Chasmodes* (Springer, 1959) and in the flatfish genus *Gymnachirus* (Dawson, 1964). In each of these cases, small areas of geographical overlap have been found but these do not occur for all three genera in the same part of the northern Gulf.

Although many studies, Bright & Cashman (1974), Caldwell (1959, 1963), Causey (1969), Hubbs (1963, 1965), Moseley (1966), Smith (in

Table E-1 Comparison of Trawl Fish Catches in Relation to Shelf Zone for the Upper and Central Texas Continental Shelf*

Shelf Zone	Diversity (No. of spp.)	Abundance (No./Haul)	Dominant Groups	Dominant Species
Inner shelf (4-23m)	61	161.9	searobins (26%) flatfishes (21%) drums (20%)	blackfin searobin (*Prionotus rubio*) spotted seatrout (*Cynoscion nebulosus*) Atlantic threadfin (*Polydactylus octonemus*)
Intermediate shelf (24-65m)	48	245.1	flatfishes (45%) seabasses (20%) searobins (10%)	shoal flounder (*Syacium gunteri*) spotted whiff (*Citharichthys macrops*) blackear seabass (*Serranus atrobranchus*)
Outer shelf (66-120m)	23	312.7	searobins (49%) lizardfishes (31%)	shortwing searobin (*Prionotus stearnsi*) largescale lizardfish (*Sauridia brasiliensis*) blackear seabass (*Serranus atrobranchus*)

* By R. M. Darnell (Id. by C. Cashman). Most of the collections were made during the period May-July, 1971. Source: James, et al. (1972).

press), Smith, et al., (in press), Walls (1973) have been conducted concerning the fish fauna of offshore banks (hard substrates) of the northern Gulf of Mexico, only one study has been directed towards studying the fish fauna of offshore oil platforms. Sonnier, et al. (in press) made observations, photographs and collections of fishes on the western reefs of the outer Louisiana continental shelf and around oil platforms and verified the presence of an extensive tropical fish fauna. Of 105 species recorded, about 50% were tropical species either unreported or rarely reported from the northwestern Gulf of Mexico. Reefs contained more species than oil platforms, although a number were common to both (Table E-2) and 12 species were found only around platforms (Table E-3). The 67 species of fish found at the deeper reefs were all typical Caribbean—West Indian species. No estimate concerning biomass between the two sides of the Gulf of Mexico has been reported.

Sonnier, et al. (in press) found that platforms generally show a lesser growth of epifauna than the reefs studied, suggesting fewer niches, so their estimate of 49 species occurring on platforms and 93 species on the reefs probably reflects platforms studied were inshore of the deeper reefs and subject to lower temperatures possibly reducing the number of species near platforms.

Marine Mammals, Birds and Sea Turtles

Several species of marine mammals, birds and sea turtles constitute the wildlife species of the open Gulf. However, due to the difficulty in obtaining data, information is rather scarce in most of the populations.

Woolfenden and Schreiber (1973) summarized data available on the pelagic birds in the Gulf of Mexico. Little is known about the birds of the Gulf of Mexico, however, the records that do exist suggest that the Wilson Petrel is one of the few species of open Gulf waters that occurs regularly in fairly large numbers. The species is virtually never seen within sight of land, and little information is available regarding its food.

Four species of boobies are known to occur in the Gulf of Mexico; however, only one is common in the eastern Gulf, the Gannet. The Gannet breeds in the North Atlantic. The breeding ranges of the three species rare in the eastern Gulf, the Masked Booby *Sula dactylatra*, Red-footed Booby *S. sula* and Brown Booby *S. leucagaster*, though not well known, do not include the eastern Gulf of Mexico.

Jaegers are seabirds that are rarely observed from land. All three species occur in the Gulf of Mexico, but it is difficult to establish the relative numbers of each because all are similar in appearance and infrequently seen. Certainly the Long-tailed Jaeger *Stercorarius longicaudus* is rarest and the Pomarine Jaeger *S. pomarinus* may be less abundant than the Parasitic Jaeger (Williams, 1965).

Sooty Terns and Brown Noddies are true pelagic birds, and the Sooty may be the commonest bird in the Gulf of Mexico. Both these pelagic species disappear from the Tortugas area after their annual breeding (Dinsmore, 1972) and almost never are they seen along the mainland.

Records of Lowery (1960) indicated that oceanic birds in Louisiana waters included shearwaters, jaegers and petrels. It would be reasonable to expect these species to occur throughout the Gulf of Mexico.

During the winter season, hundreds of thousands of waterfowl occupy virtually the entire length of the Gulf coast. Primary species utilizing the open Gulf include, scaups, redheads, canvasbacks, and scoters.

According to data from Rahn and Gelback (1972), four species of sea turtles occur in Texas waters. These include the leatherbacks, hawksbill, Atlantic ridley and green turtles. All but the green turtle are listed as endangered species by the U.S. Fish and Wildlife Service (1974). Little can be said about their distributions. They may be occasionally observed floating on the surface of the water and are susceptible to being caught by commercial fishermen. However, the few coastal observations and declining occurrences in trawl nets indicate a scarcity of the animals.

The loggerhead is apparently the only species that nests on beaches in the Gulf of Mexico. Reports indicate the species may nest on the Chandeleur Islands off the Louisiana coast. The primary nesting sites are located on the beaches of the western and southern half of Florida in the Gulf. Sea turtle nesting areas are depicted in Visual No. 4, Vol. III of the western and central Gulf visuals.

The primary problems confronting the turtles in the Gulf are disturbance of nesting sites and drowning in shrimp trawling nets. It is apparent that the general populations are in jeopardy and are probably decreasing.

Table E-2 Species Occurring Both at Platforms and Reef Areas Sampled

Species	Reef Area A	Reef Area B	Reef Area C	Platforms
Dasyatis americana-Southern Stingray	C [1/]	C	C	R
Epinephelus adscensionis - Rock hind	C	C	C	O
E. itajara - Jewfish	R			C
Mycteroperca phenax - Scamp	C	C	C	C
Apogon maculatus - Flamefish	C	C	C	O
Rachycentron canadum - Cobia	O			C
Caranx hippos - Crevalle jack	C	C	C	C
C. latus - Horse-eye jack	C	C	C	C
Elagatis bipinnulata - Rainbow runner		O	C	R
Selene vomer - Lookdown	C	O		C
Seriola dumerili - Greater amberjack	C	C	C	C
Lutjanus campechanus - Redsnapper	C	C		C
L. cyanopterus - Cubera snapper	R			R
L. griseus - Gray snapper	C	O		C
Rhomboplites aurorubens - Vermilion snapper	O	C	C	O
Haemulon aurolineatum - Tomtate	C			O

1/ C = Common
O = Occasional
R = Rare
(Source: Sonnier et al.,in press)

Table E-2 (Continued)

Species	Reef Area A	Reef Area B	Reef Area C	Platforms
Archosargus probatocephalus - Sheepshead	R			C
Equetus umbrosus - Cubbyu	R			R
Kyphosus sectatrix - Bermuda chub	C	C		C
Chaetodon ocellatus - Spotfin butterfly fish	O	O	O	O
Holacanthus bermudensis - Blue angel fish	C	C	C	C
H. ciliaris - Queen angelfish	O	O	O	O
H. tricolor - Rock beauty		O	O	R
Pomacanthus paru - French angelfish	C	C	C	C
Pomacentrus variabilis - Cocoa damselfish	C	C	C	C
Amblycirrhitus pinos - Redspotted harkfish		O	O	R
Bodianus pulchellus - Spotfin hogfish			O	O
B. rufus - Spanish hogfish	C	C	C	R
Thalassoma bifasciatum - Bluehead	C	C	C	O
Sphyraena barracuda - Great barracuda	C	C	C	C
Scomberomorus cavalla - King mackerel	C			C
Aluterus scriptus - Scrawled filefish			R	R
Balistes capriscus - Gray trigger fish	C	C	C	C

Table E-2 (Continued)

Species	Reef Area A	Reef Area B	Reef Area C	Platforms
B. vetula - Queen triggerfish		R	O	R
Cantherines pullus - Orange-spotted filefish		R		O
Canthidermis sufflamen - Ocean triggerfish	O	C	C	C
Canthigaster rostrata - Sharpnose puffer	O	O	O	O
Totals	30	28	25	37

Table E-3 Species Primarily Associated with Platforms

Species	
Epinephelus nigritus - Warsaw grouper	C 1/
Rypticus maculatus - Whitespotted soapfish	C
Caranx crysos - Blue runner	C
Chloroscombrus chrysurus - Atlantic bumper	R
Vomer setapinnis - Atlantic moonfish	R
Ocyurus chrysurus - Yellowtail snapper	O
Chaetodipterus faber - Atlantic spadefish	C
Pomacanthus arcuatus - Gray angelfish	R
Hypleurochilus geminatus - Crested blenny	C
Acanthurus coeruleus - Blue tang	R
Aluterus schoepfi - Orange filefish	R
Monacanthus hispidus - Planehead filefish	C

1/ C = Common
O = Occasional
R = Rare
(Source: Sonnier et al., in press)

Several species of marine mammals are recorded for the waters of the Gulf of Mexico, Table E-4. However, most of these records are based on stranded individuals or fortuitous sightings and do not indicate population status.

Schmidly and Melcher (1974), Lowery (1974), and Caldwell (1973) have covered the available data for the Gulf. It appears that the spotted dolphin and bottle-nosed dolphin are the only marine mammals of any abundance in the Gulf of Mexico in this assessment area.

Biological Sensitive Areas

Three tracts (10, 11, and 61) have been identified in this proposed sale which may contain fishing or hard bank biotic assemblages, based on vertical relief in the area. Tracts 10 and 11 are located in the eastern portion of Saline Bank. The relief of this area varies from approximately 1.8 to 5.5 meters (C&GS Chart 1116A). Tract 61 has approximately 91 meters of relief. The types of bottom characteristics and biota are unknown.

Table E-4 MARINE MAMMALS OF THE GULF OF MEXICO

Common Name	Scientific Name
Block Right Whale	Balena glacialis
Humpback Whale	Megaptera novaengliae
Minke Whale	Balaeoptera acutorostrata
Bryde Whale	B. edeni
Fin Whale	B. physalus
False Killer Whale	Pseudorca crassidena
Killer Whale	Orcinus orca
Short-finned Pilot Whale	Globicephala macrorhyncha
Sperm Whale	Physeter catodon
Pygmy Sperm Whale	Kogia breviceps
Dwarf Sperm Whale	K. simus
Antillean Beaked Whale	Mesoplodon europaeus
Goose-beaked Whale	Ziphius cavirostris
Rough-toothed Dolphin	Steno bredanensis
Risso's Dolphin	Grampus griseus
Common Dolphin	Delphinus delphis
Bottlenose Dolphin	Tursiops truncatus
Long-snouted Dolphin	Stenella longirostris
Bridled Dolphin	S. frontalis
Euphrosyne Dolphin	S. caeruleoalba
Spotted Dolphin	S. plagiodon
Manatee West Indian (Florida)	Trichechus manatus
California Sea Lion	Zolophus californianus

Biological Environment of the Coastal Zone

Data on the biological environment of the coastal zone for the western and central Gulf has been treated in previous environmental statements prepared by the Bureau of Land Management. Reference to the following environmental statements are suggested for a more detailed discussion on the biological environment and communities of the coastal zone.

Louisiana—Final Environmental Statement, Vol. 1, OCS Sale No. 36, pp. 122-198

Texas—Final Environmental Statement, Vol. 1, OCS Sale No. 37, pp. 137-175

Gulf of Mexico General Lease Sale—Final Environmental Statement, Vol. 1, OCS Sale No. 41, pp. 132-147

The area under consideration in this proposed sale is the band of coastal lands and waters from the tidal zone landward to the level of six meters above MSL (mean sea level), or roughly 48 meters inland and extending along the northern Gulf of Mexico.

The direct distance along the arc of the Texas coastline between its political boundaries is roughly 595 km. The extent of mainland shoreline, however, as described along its many dendritic bays, is approximately 2,896 km. Eight major bay systems penetrate the Texas coast, and all except the Sabine River estuary are fronted by a portion of a 483 km chain of barrier islands and peninsulas. The uniqueness of this coastal barrier is two-fold: It is the longest barrier island system in the world and is comparable in magnitude to the Great Barrier Reef off western Australia; and less than a dozen inlets and passes provide the narrow arteries for exchange between the embayed waters and the open sea.

The seaward margin of the Texas coast, comprised mostly of barrier islands, is a nearly continuous strand of sand beaches. Shoreward of the beaches is the man-made Intracoastal Canal which courses the entire length of the coast. The area of coastal marsh is roughly 1,611 square kilometers, but is limited to a narrow band along the coast with its greatest extent at the Sabine area and then diminishes southward.

The Mississippi contributes most of the nutrients to the estuaries of Louisiana—the most extensive in the Gulf—which supports the third largest shrimp production and the second largest oyster production in the United States (U.S. Dept. of Commerce, 1974).

East of the Mississippi Delta, the proportion of estuaries to the coastal zone diminishes and becomes more commonly characterized by high energy sand beaches. The wetlands which are present are extremely valuable in terms of biological productivity.

The paramount feature of this area of the Gulf coast is the Mississippi River Delta and its associated 17 million or more hectares of marsh and estuaries. The Mississippi watershed covers about one-third of the United States, and the resultant freshwater discharge is responsible for the major saltwater dilutions within the central Gulf Coast region.

Along the northwest Gulf Coast, the marshlands diminish rapidly into a narrow band along the coast, and are nearly absent in the semi-arid regions of south Texas. A significant portion of the coastal zone, however, is composed of a vast system of bays and lagoons which are engendered for the most part by the extensive system of barrier islands. The marshes of this geographic area are depicted in Visual No. 6.

Salt Marsh

Most salt marshes exhibit distinct zonation by the most abundant plants. This zonation is controlled by a variety of factors including soil types, soil salinity, tide, elevation, drainage characteristics and pH. The extent of saline intrusion into the marsh depends to a large degree on the rate of percolation (movement through soils) of saltwater at high tide (Jackson, 1952), and the location of points of influx of freshwater from the mainland. In the vicinity of the Mississippi Delta, the saline marsh is generally adjacent to the beach rim and may vary from two to 24 meters in width. The saline marsh merges with the broad band of brackish marsh which is further removed from the sea rim and vegetated by wiregrass, coco, and three-cornered grass.

The comparatively small number of plant species of the saltmarsh limits the number of available niches in which organisms may live. Chabreck (1972) recorded only 17 plant species present in the coastal saltmarsh of Louisiana, with saltmarsh cordgrass (*Spartina alterniflora*) being the dominant species. However, with the inland marsh succession, habitat complexity increases significantly.

According to Humm (1973), vegetation consists primarily of three grass species of rush and several species of forbs.

Salt marsh grass (*Spartina alterniflora*) comprises the most seaward of the vegetation zones where it endures the deepest and longest inundation by salt water. Black rush (*Juncus roemerianus*) inhabits the next zone inland and therefore occurs on slightly higher ground. This species forms almost pure stands to heights of 1.8 to 2 meters and functions to slow down tidal penetration. The third zone inland is dominated by salt grasses (*Distichlis spicata and Spartina patens*). This zone is rarely inundated except during high tides.

Salt marshes support considerable populations of rails, sparrows, ducks, numerous shorebirds and a few reptiles. The area also functions as a hatchery for fish and invertebrates which are essential to the maintenance of the higher vertebrates.

Brackish Marsh

Brackish marshes are usually situated between the seaward salt marsh and landward intermediate and fresher marshes. These brackish marshes are located extensively in southeastern Texas and throughout the coast of Louisiana.

Salinities vary annually between an average low of 3.4 ppt to an average high of 16.7 ppt. Highest salinities occur in June, or in the drought period (Palmisano, 1971).

Plant species diversity increases as one approaches the upland environment from the marsh. Forty species of plants (Chabreck, 1970) have been recorded in the brackish marsh. The dominant species wiregrass, (*Spartina patens*), comprises 55% of the total vegetation. Saltgrass, (*Distichilis spicata*), makes up 13% of the remaining 38 species. Only five other species have been recorded with coverage greater than two to five percent.

Intermediate Marsh

Intermediate marshes extend further inland than brackish marshes. In the Gulf of Mexico coastal zone they are distributed predominantly in the southwestern region of Louisiana and southeastern Texas.

A more diverse vegetation occurs in the intermediate marsh than the brackish or saline marshes. Based on the data given by Chabreck (1970), 54 species of plants or 35% more than in the brackish zone occur in the intermediate marshes. The dominant wiregrass makes up a third of the vegetation. Roseau (*Phragmites communis*), and bulltongue (*Sagittaria falcata*), comprise 6.6% and 6.5% of the vegetation, respectively.

Freshwater Marsh

The only freshwater marsh in the area of this sale proposal is situated in the more central region of the Mississippi Delta near the distributary passes. Major species of vegetation in this marsh are: roseau cane, Eurasion water milfoil, alligator weed, duck weed, water hyacinth, dogtooth grass, bulltongue, and pondweed (Stone, 1972).

Barrier Islands

Several groups of barrier islands front the coastal states of Texas and Louisiana. Many offer environments distinct from the other island groups. Following is a list of the major barrier islands for the western and central Gulf of Mexico.

1. Padre Island—Texas
2. Mustang Island—Texas
3. Matagorda Island—Texas
4. Galveston Island—Texas
5. Grande Terre Islands—Louisiana
6. Isles Dernieres—Louisiana
7. Timbalier Islands—Louisiana
8. Grande Isle—Louisiana
9. Chandeleur Islands—Louisiana

Seagrasses

Seagrasses consist of species of flowering plants that grow completely submerged (some are tidally emergent) in brackish to saline waters. They are limited to water where sunlight penetration permits photosynthesis, such as are found in the shallow waters of bays and around islands in areas of low turbidity.

Marine grass beds support one of the highest biomass densities in the marine environment. They not only provide a valuable food source for migratory waterfowl and shorebirds, but are also prime nursery grounds for shrimp, crabs and fishes of all types. While few animals feed on the grasses, many feed on organisms which attach to or live on them; viz., snails and mussels.

Seagrass communities are fragile ecosystems which advance and decline readily in response to minor changes in water quality, turbidity, or sediment loads and are vulnerable to storm damage. The U.S. Fish and Wildlife Service (personal communication) reported that the largest of these marine meadow communities in Louisiana is located immediately west of the Chandeleur Islands from Whitehouse Point south to the area

of Polo Island. Species include *Syringodium filiforme*, *Thalassia testudinum*, *Halodule beaudetti*, *Halophila engelmanni* and *Ruppia maritima*. Data is not available on other seagrass communities in this proposed sale area.

Estuaries and Embayments

Estuaries and bays are highly productive ecosystems. They receive nutrients from upland areas via major river systems, especially during spring flooding. They also receive the nutrient wash-out from tidal flushing of the salt marsh, particularly in mid-winter when marsh grass of the previous season is decomposing. The dynamics of this system holds for the estuarine areas of Louisiana. Diagrammatic cross sections including a listing of representative invertebrate species are shown in Figure F-1 (Collard and D'Asaro, 1973).

Beaches

Much of the Texas and Louisiana coastline is protected from the full force of oceanic waves by barrier islands. The seaward margins of these islands, which are exposed to waves formed at sea, are called high energy beaches. Organisms living in such areas are adapted to survive the scouring force of wave action by burrowing the sand. The sand bug (*Emerita talpoida*), and the butterfly shell, variable wedge shell (*Donax variabilis*), etc., (among others) can bury themselves almost instantaneously. This ability enables them to live directly in the surf zone (Collard and D'Asaro, 1973). Figure F-2 depicts many of the same invertebrates found west of Louisiana.

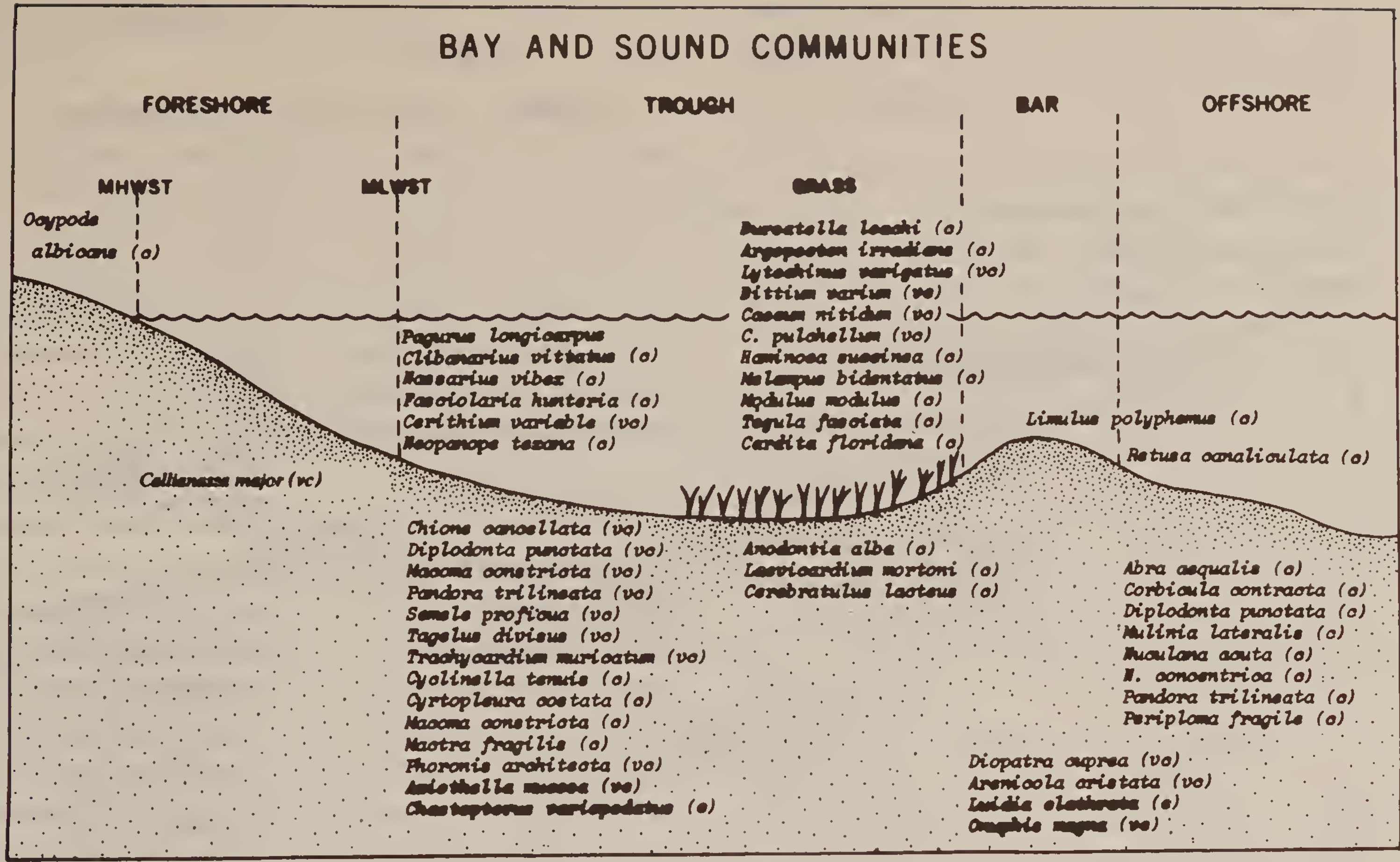


Figure F-1 Bay and sound communities: Carolinian affinities. Most species listed are wide ranging, occurring in sand and grass. Typical of northern Gulf Coast from Louisiana to Cedar Key, Florida (from Collard and D'Asaro, 1973).

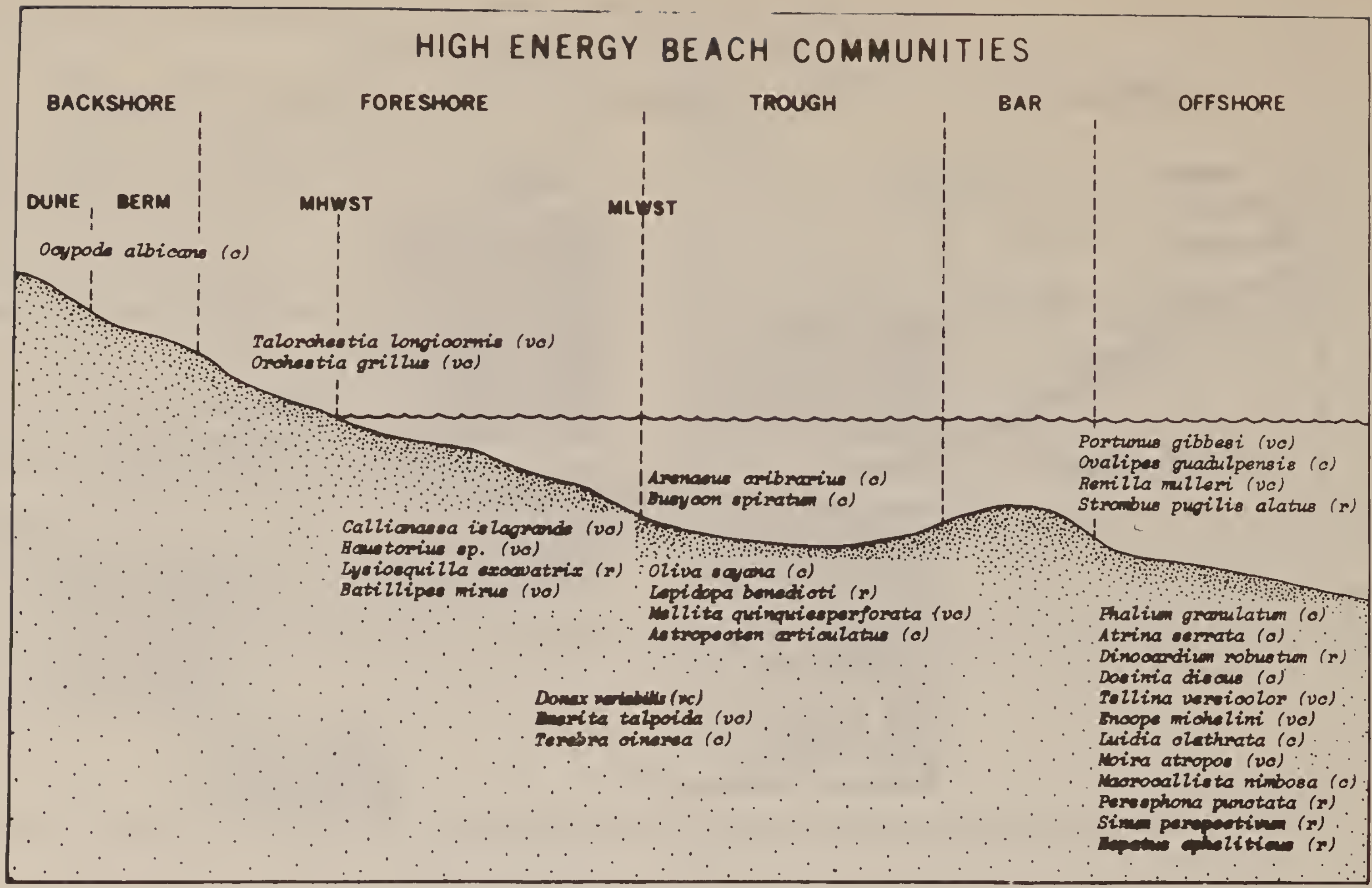


Figure F-2 High Energy Beach Communities. Composition of these communities is essentially the same from the Mississippi barrier islands to Cape Sable, Florida (from Collard and D'Asaro, 1973).

Human Utilization

Land Use

Land use information is available for portions of the coastal zones of Texas and Louisiana, but at varying scales, specifications, interpretations and stages of completion. For some regions, detailed land information is available, but formats are often inconsistent with adjacent regions. For the purpose of this discussion, therefore, only references which allow a generalized and consistent overview of the Texas and Louisiana coastal zone were used.

Texas

The most comprehensive and current land use and ownership mapping, statistical inventories and descriptions for coastal Texas can be found in the partially completed series, Environmental Geologic Atlas of the Texas Coastal Zone (Fisher, et al., 1973) which delineates the coastal line into seven reaches. Since mapping has been published for only three of the reaches, this information was not utilized.

Land use in the Texas coastal zone is highly variable both within and between regions and this requires its portrayal in general categories at gross scales. More detailed categorical discussions can be found elsewhere under appropriate headings.

In the upper reaches, land use pressures are generally more intense because of the major population and industrial centers in that region as described in the Environmental Geological Atlas of the Texas Coastal Zone—Beaumont—Port Arthur Area (Fisher et al., 1973). A number of factors contribute to diversified and intensive land and water use, especially in the Houston, Galveston, Beaumont, Port Arthur and Orange areas. First, it is an area amply endowed with mineral resources which supports one of the major petroleum refining and petrochemical centers of the world. Secondly, it is an area with fertile and productive agricultural lands and, finally, it contains major port facilities with extensive intracoastal waterways and ship channels that have led to a high-volume flow of imports and exports.

Many of the factors have led to diverse land and water use in the Beaumont-Port Arthur area and have also led to current and potential limitations and conflicts. Many of the resources of the area have varied uses, both present and potential. For example, water bodies are used simultaneously for transportation, commercial and sport fishing, recreation, oil and gas well locations, pipeline routes, as an area to fill for real estate development, and as a part of a waste disposal system.

The area is undergoing rapid and dramatic physical change involving active shoreline processes, hurricane flooding and damage, subsidence and surface faulting. These changes conflict with a variety of land and water uses.

In the lower reaches of the Texas coastal zone, many of the specific land uses are similar, but the acreage proportions differ from the upper reaches. Urban and industrial stress is less intense, and with the exception of the developed areas near Brownsville, Harlingen and Corpus Christi land use is generally more extensive, with large acreages devoted to agriculture, rangeland and ranching.

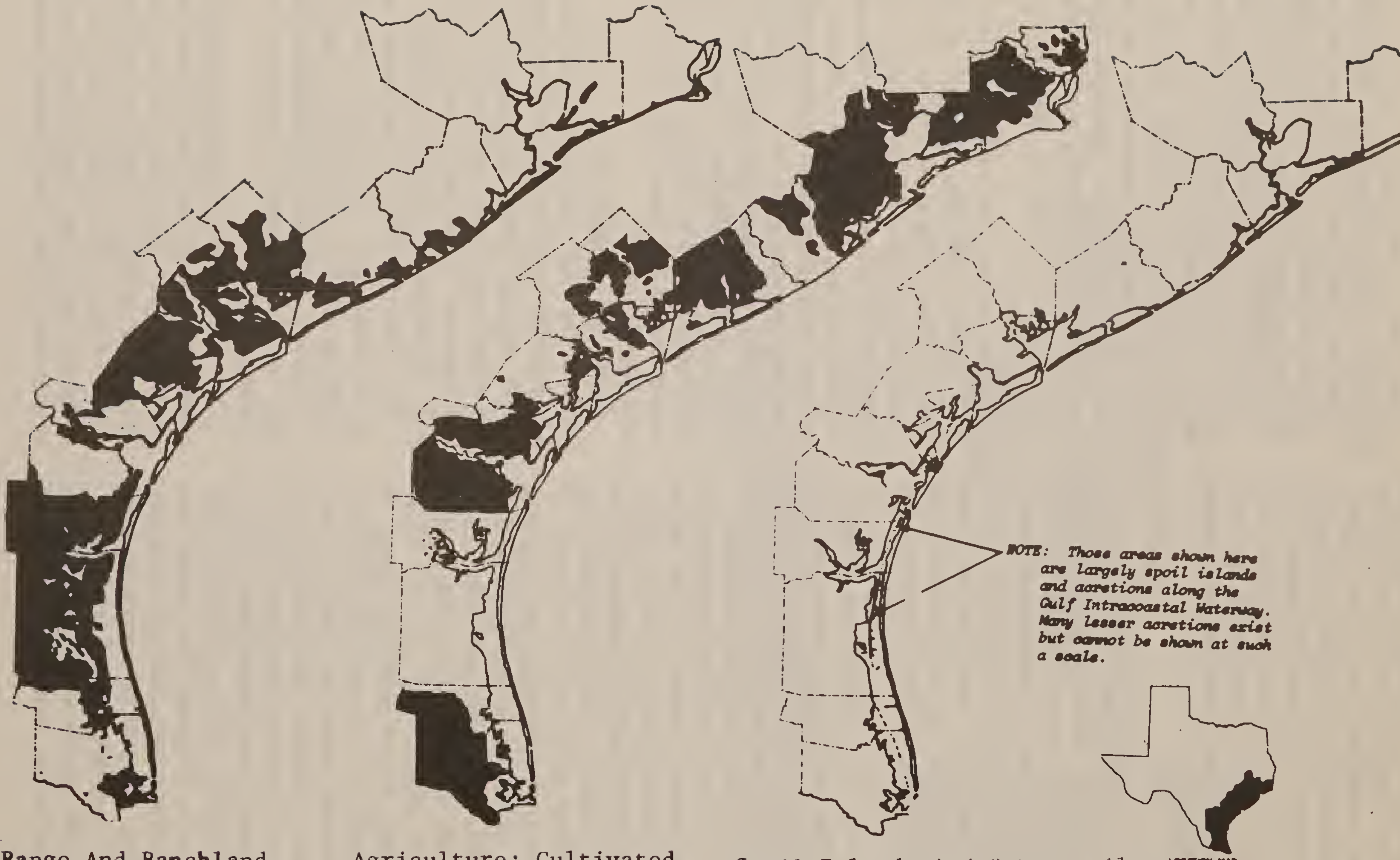
Patterns of land use and intensity can be found in a report, Land Use Patterns in the Texas Coastal Zone, (Flawn and Fisher, 1970). Highly generalized patterns of gross categories are shown in Figures G-1, 2 and 3 and a statistical summary of these acreages is shown in Table G-1. The following is a summary of the coastal counties.

A brief discussion of these principal land and water uses and their distribution within the 18 county coastal zone follows. A more comprehensive discussion can be found in the Final Environmental Impact Statement FES 74-63 written for OCS Sale No. 37.

Agriculture—Approximately 13,261 sq. km (41%) of the total land in the Texas coastal zone are presently under cultivation. Concentration is on the original prairie grasslands of the central and upper coastal zone. Agricultural use becomes less intensive in the south Texas coastal zone with the progressive decrease in rainfall.

Sixty percent of the total production of rice in Texas comes from the coastal zone. The main producing counties are Brazoria, Chambers, Harris, Jackson, Jefferson and Matagorda. Relatively high rainfall and extensive irrigation are main contributing factors.

The second most important agricultural crop produced in the coastal zone is grain sorghums, accounting for about 12% of the total state production. Principal yields are centered in the Corpus Christi area (Nueces and San Patricio counties) and in the southernmost part of the coastal zone (Willacy and Cameron counties).



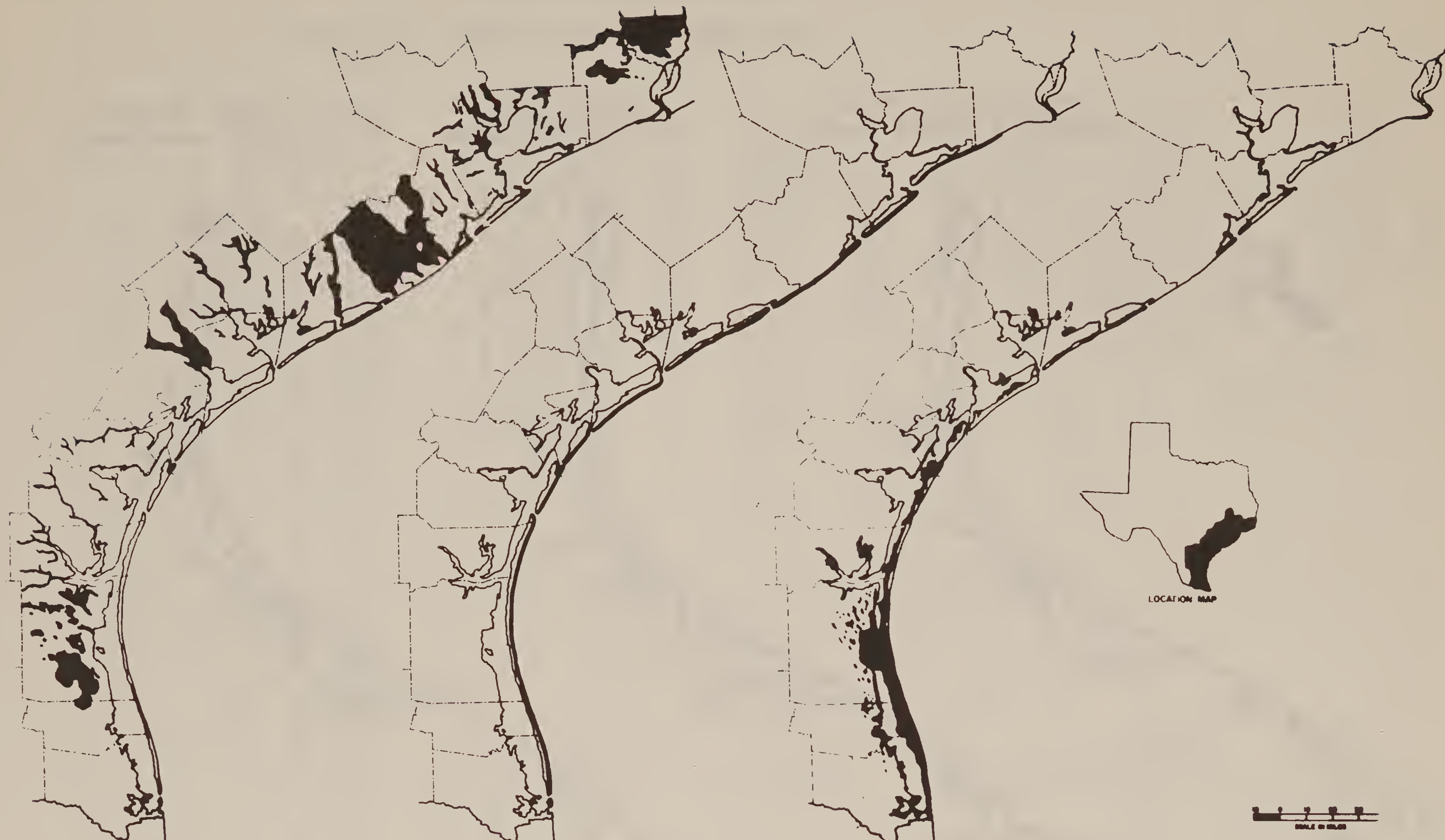
Range And Ranchland In The Coastal Zone

Agriculture: Cultivated Lands In The Coastal Zone

Spoil Islands And Other Built-Up Lands In The Coastal Zone

Figure G-1 LAND USE IN THE COASTAL ZONE

(Flawn and Fisher, 1970)



TIMBER - WOODLANDS IN THE COASTAL ZONE

RECREATIONAL BEACHES IN THE COASTAL ZONE

BARREN LANDS IN THE COASTAL ZONE

Figure G-2 LAND USE IN THE COASTAL ZONE

(Flawn and Fisher, 1970)

Swamplands In The Coastal Zone

Marshlands In The Coastal Zone

Formal Wildlife Refuges In The Coastal Zone

Figure G-3 LAND USE IN THE COASTAL ZONE
(Flawn and Fisher, 1970)

Table G-1 Statistical Summary of Land Use - Texas Coastal Counties

Use	Totals
Total area 1/	16128.0
Total land area 2/	13818.0 - 86.0
Total water area 2/	2310.0 - 14.0
Land Areas	
Agriculture 3/	5117.0 - 37.0
Range and ranch 3/	4425.0 - 32.0
Woodland and timber 3/	1609.0 - 11.6
Marsh and Swamp 3/	762.7 - 5.5
Urban industrial and residential 3/	969.7 - 7.0
Recreational 3/	23.3 - 0.2
Subaerial spoil 3/	84.7 - 0.6
Made land 3/	33.8 - 0.2
Wildlife refuge 3/	213.4 - 1.5
Barren land 3/	579.4 - 4.2
Water Areas	
Bays 2/	2075.3 - 12.9
Artificial reservoirs 1/	64.7
Natural fresh water bodies 1/	170.0
Other Features	
Bay shoreline 4/	1419.3
Open ocean shoreline 4/	373.1
Total shoreline 4/	1792.4
Drainage channels 4/	3120.0
Transportation canals 4/	668.0
Hurricane flood areas 4/	3208.0 - 23.3

1/ Measured in square miles.
2/ Measured in both square miles (left number) and % of total area (right number).
3/ Measured in both square miles (left number) and % of total land area (right number).
4/ Measured in linear miles.

Source: Flawn and Fisher, 1970

Use of the coastal zone land in the production of cotton is significant only in the coastal bend (Calhoun, Nueces, and San Patricio counties) and in the lower Rio Grande Valley (Willacy County).

Minor quantities of corn, hay, oats and wheat are produced accounting for less than three percent of the total state production. Concentration of crops is in the central coastal zone (Matagorda, Brazoria and Harris counties) and is co-extensive with the area of principal beef production.

Range and ranchland: Approximately 42% 11,461 sq. km of the total area of the coastal zone is devoted to range and ranch sites; marshlands used as range sites include an additional 1,968 sq. km. Principal sites include the more arid region of south Texas, the low-lying coastal marshes, and the nonwooded barrier islands and levees of the central and upper coastal zone. The grazing of beef is the principal use of the range land and is most significant in Brazoria, Harris, Jackson, Matagorda and Victoria counties.

Woodland and timber: Woodlands occur throughout the coastal zone of Texas but are most extensive in Orange, Brazoria, Matagorda and Kenedy counties. Smaller areas of woodlands occur along streams, including low-swamp areas with water-tolerant vegetation, and on certain of the abandoned Pleistocene barrier island sands. Total woodland area in the coastal zone is approximately 4,144 sq. km. Principal vegetation in the upper coastal zone woodlands includes pine and mixed hardwoods; in the central coastal zone, a variety of water-tolerant hardwoods; and in the southern coastal zone, oak.

Marshlands: Approximately 1,968 sq. km of the Texas coastal zone is marshlands or wetlands. These include dominantly low-lying areas, the landward sides of barrier islands, and low areas at the terminus of major river valleys and associated bayhead deltas. Salt, brackish, and fresh-water marshes are restricted to areas below four feet above mean sea level. Grasses of varying tolerance to fresh and salt water are the sole vegetation. Most of the marshlands are used for the grazing of beef cattle.

Urban industrial and residential: The principal urban and industrial concentration is in the upper part of the coastal zone. Highest concentrations are in Brazoria (Freeport area), Jefferson (Galveston area), Harris (Houston area) and Nueces (Corpus Christi area) counties. Nearly 2,590 sq. km are included in this use category.

Recreation: The area designated as recreation is primarily the public beaches of the coastal zone. This amounts to a total area of about 60 sq. km. Not included are a variety of public parks and other recreational areas, surface waters and the Padre Island National Seashore.

Formal wildlife refuges: (Source: Texas A & M University, 1972). Five major national wildlife refuges are designated in the Texas coastal zone including: Anahuac Refuge (4,023 hectares) in Chambers County; Brazoria (3,857 hectares) and San Bernard (6,038 hectares) refuges in Brazoria County; Aransas Refuge (22,190 hectares) in Calhoun, Aransas and Refugio counties; and Laguna Atascosa Refuge (18,272 hectares) in Cameron County. There is one state owned wildlife management area, the J. D. Murphee Wildlife Management Area (3,400 hectares) in Chambers County.

Barren lands: Barren lands comprise nearly 1,502 sq. km in the coastal zone. Principal distribution of these lands is in the semiarid area from Kleberg County south, and includes extensive wind-tidal flats landward of Padre Island as well as some of the active dune fields on the south Texas sand sheet.

Made land and spoil: Made land, or land built up to higher levels by grading, represents about 88 sq. km in the coastal zone. This occurs principally in metropolitan areas along the coast. Some of the spoil areas have re-established vegetation; other areas are barren.

Water: The extensive bays of the coastal zone comprise the principal surface-water bodies covering approximately 5,439 sq. km and making up about 13% of the total surveyed area. Principal bays and estuaries include Sabine Lake; Trinity-Galveston Bay, including East and West Bays; Matagorda Bay, including East Matagorda Bay; Espiritu Santo Bay; Lavaca Bay; San Antonio Bay; Aransas Bay; Copano Bay; Corpus Christi Bay; Baffin Bay; and Laguna Madre.

Fresh water bodies existing either as natural water bodies or as artificial reservoirs comprise the other water areas of the coastal zone. The surface area of natural water bodies is about 4,403 sq. km; artificial reservoirs cover about 168 sq. km.

Hurricane flood: Approximately 8,309 sq. km of the lower parts of the Texas coastal zone have been inundated by salt water from surges of hurricanes Carla and Beulah during the past decade.

Particularly prone to flooding are the low coastal marshes and the lower reaches of the main river valleys.

Shoreline: Total shoreline in the Texas coastal zone amounts to slightly over 3,041 km. Of this total, 2,283 km are bay shoreline and 151 hectares open-ocean or gulf shoreline. The shoreline is a dynamic zone subject to constant change in the form of erosion or accretion and is thus subject to change in total length.

Canals: An extensive canal system has been developed in the Texas coastal zone including transportation, irrigation and drainage canals. Major transportation canals total 1,075 km within the surveyed part of the coastal zone. Approximately 5,020 km of irrigation and drainage canals have been cut, mostly associated with agricultural lands.

Specific to the immediate shoreline is a land use study (Texas A & M University, 1972), which divided the coast into beach segments (Fig. G-4) for the purpose of describing shoreline use. Each section of the coast is 4.8 km in length along the beach and extends from the ocean beach back to the approximate limit of hurricane high water, which was assumed to be 3.7 m elevation. The following description of the physical and land use characteristics along the Texas coastal shoreline was abstracted from this study.

Shoreline segments 1-40: Padre Island, a barrier island between the Gulf of Mexico and Laguna Madre, extends south along the lower Texas coast for about 182 km ranging in width from a few hundred yards to about 4.8 km. It has wide, sandy beaches backed by sand dunes up to 12.2 m, grass flats and mud flats.

The long mainland shore of Laguna Madre, extending south about 188 km from Encinal Peninsula to Port Isabel, is essentially underdeveloped privately owned land. The area adjacent to the shore is largely unpopulated. Baffin Bay has some private residences and recreational facilities along its west bank. Port Mansfield is a sport and commercial fishing center with harbor facilities for fishing vessels and small craft. The community has a small number of permanent residents operating establishments catering to tourists, hunters and fishermen. Laguna Atascosa National Wildlife Refuge borders a large portion of the Laguna Madre shore between the mouth of the Arroyo Colorado and a point about 12.9 km north of Port Isabel. Between the wildlife refuge and Port Isabel much of the area has been subdivided for homes. The Port Isabel waterfront is lined with hotels, docks, piers, boat launching ramps and seafood handling and processing establishments.

Brazos Island and the South Bay area between Port Isabel and the Rio Grande are mostly undeveloped. The Gulf shore of Brazos Island, including a 3.2 km strip dedicated as a state park, is used for public recreation. Some private housing and a few tourist service establishments are located along this coast.

Except for some public recreational and private residential and commercial developments at its northern and southern extremities, there are no other significant developments on Padre Island.

The federal navigation channel from the Gulf of Mexico to Port Mansfield extends through Padre Island about 61 km north to Port Isabel. Most of the island north of the Port Mansfield Channel is occupied by the Padre Island National Seashore, a park 129.5 km long dedicated to preserving that portion of the island in its natural state for the public's enjoyment.

Shoreline segments 41-51: The major portion of St. Joseph Island is used for ranching and private recreation. A small portion of the southern tip of the island, adjacent to the Aransas Pass Navigation Channel, is owned by the Federal Government. Mustang Island extends from the Aransas Pass Navigation Channel to Corpus Christi Pass. The 26 km long beach front is a very popular recreational center for the south Texas region. Sand dunes up to 7.6 km in height lie behind the beach front. The island provides protection against hurricane tides and waves for the island areas around Corpus Christi Bay. The island has numerous beach homes and recreational facilities. Port Aransas, located on the northern end of the island, is the only town on Mustang Island.

A causeway and ferry provide access to the northern end of the island while the John F. Kennedy Causeway provides access to the south end. The north shore of Mesquite Bay and the east shore of Blackjack Peninsula are part of the Aransas National Wildlife Refuge. The west bank of St. Charles Bay is undeveloped. The perimeter of Copano Bay has scattered developments of homes, fishing and hunting camps, farm buildings, and oil fields and supporting facilities. Most of the northwest shores of Aransas and Redfish Bays are well developed with homes. The cities of

FIG G-4 Three-mile Environmental Inventory Shoreline Segments.

Rockport and Aransas Pass have many businesses catering to tourists and recreationists. Oil fields and permanent and summer residences occupy the northeast shore of Corpus Christi Bay. The northwest shore of the bay has several residential subdivisions on bluffs which range up to nine km above sea level. Oil and gas wells, piers and docks constitute the major development on the north shore of Neuces Bay. Much of the shore of Neuces Bay is undeveloped and is used as a spoil area for dredging operations in the Corpus Christi Ship Channel.

Corpus Christi, the largest city on the Texas coast, fronts the west and south shores of Corpus Christi Bay about 26 km of highly developed and densely populated urban areas. Corpus Christi is an important sea port and industrial center for petroleum and agricultural products and is also a major tourist and convention center.

A large part of the Oso Bay is not developed. The University of Corpus Christi occupies an island connected to the mainland by a causeway at the shore of Laguna Madre. Part of the Corpus Christi Naval Air Station, the community of Flour Bluff and a small port serving fishing interests and nearby oil and gas fields is located along the Encinal Peninsula shore. Many boating supply, bait, and fishing tackle businesses and launching ramps are located along the John F. Kennedy Causeway.

Shoreline segments 52-61: Matagorda Island is a remote area accessible only by boat or aircraft. About 60 percent of the 48 km long island is occupied by the Matagorda Island Air Force Base and Gunnery Range. The southwestern end of the island is devoted to ranching. Recreation on the island is limited to private interests and military personnel because of the limited accessibility and restricted areas. The shoreline of Espiritu Santo, San Antonio, Guadalupe and Hynes bays are, for the most part, undeveloped. South of the town of Seadrift, the land is quite low and unsuitable for permanent type structures. Most of the upper part of San Antonio Bay is bordered by the low, marshy delta lands. The west shore of San Antonio Bay is undeveloped, except for the town of Austwell and a few scattered residences. The Aransas National Wildlife Refuge occupies the shore of San Antonio Bay from Webb Point to False Live Oak Point.

Shoreline segments 62-73: Matagorda Peninsula has the only Gulf shore in this zone. The peninsula, accessible only by boat or aircraft, is used primarily for ranching and recreation. Overnight camping is quite popular in the area near the Matagorda jetties. Two private airstrips are located on the peninsula. Most of the perimeter of Matagorda Bay is sparsely populated marshland devoted to grazing except for the town of Port O'Connor and other small communities on the western shore. The western shore has beach areas which are used for recreation where public access is available. Near Well Point, on the north shore of Matagorda Bay, about 366 km of the shore is occupied by the Texas Parks and Wildlife Marine Biology Laboratory. Farm and ranch lands border a large portion of Tres Palacios Bay Shoreline. The south part of the east shore of Lavaca Bay is low, undeveloped land. The remainder of the shore is comprised of banks and bluffs up to 7.6 km high except for some marsh area at the mouths of several streams entering the bay. The city of Port Lavaca is the largest populated area on the bay.

Shoreline segments 74-86: The northeasterly end of the Gulf shore in this area is undeveloped. It is remote and not easily accessible, but used for camping, bathing, and fishing when beach travel conditions permit. The Cedar Lakes area is undeveloped. Some areas near the mouth of Caney Creek are subdivided for beach homes. Matagorda Peninsula, southwest of the mouth of Caney Creek, is used mostly for grazing. Numerous summer homes are located in the more accessible areas near the mouth of the Colorado River. The shores of Matagorda Bay east of the Colorado River are generally undeveloped.

Shoreline segments 87-90: Shoreline development of the eastern half of this zone consists of permanent and summer homes and recreation oriented businesses. The city of Freeport and its adjacent heavy industrialization are located here. The area westward of the Freeport Harbor navigation entrance is mostly undeveloped since it is accessible only by a single road and a pontoon bridge across the Gulf Intracoastal Waterway. The beach does, however, receive some recreational use.

Shoreline segments 91-111: This zone includes the largest concentrations of shoreline development along the Texas coast. The large Galveston Bay System, comprising Galveston Bay, East Bay, Trinity Bay, West Bay and several smaller bay arms, lies behind the barrier formations of

Bolivar Peninsula, Galveston Island and Follets Island. A considerable part of Bolivar Peninsula is occupied by permanent and summer residences and numerous commercial establishments. The city of Galveston occupies about the easterly one-third of Galveston Island; the westerly two-thirds of the island has many permanent and summer-home type residential developments. A number of similar developments are located on Follets Island, west of San Luis Pass. The westerly shore of Galveston Bay is occupied by almost continuous urban development from Texas City to La Port and Baytown. Seabrook, Kemah, San Leon and a number of unincorporated communities line the bayshore in this reach. The city of Anahuac is located on the westerly shore of Trinity Bay near the mouth of the Trinity River. The Anahuac National Wildlife Refuge borders about 10 km to the north shore of East Bay.

The East Bay shoreline of Bolivar Peninsula is extensively used for recreational boating and fishing. The north shore of East Bay is mostly unoccupied except for residential development on Smith Point.

The shores of Trinity Bay are mostly undeveloped excepting the Anahuac vicinity and the vicinity of Umbrella Point and Houston Point on the north shore where numerous homes, boating and fishing camps, and some oil industry facilities are located. The upper end of Galveston Bay near Baytown is highly developed. Most of the shores are occupied by industrial, commercial and residential properties. The Galveston Bay shoreline from Morgan Point to Texas City, including the shore of Clear Lake and some of Dickinson Bay, is extensively developed with permanent and summer residences and some commercial establishments. The shoreline outside of the Texas City Hurricane Flood Protection System is, for the most part, undeveloped. The northerly shores of West, Bastrop and Christmas bays are undeveloped except for a few summer home type subdivisions.

Galveston Island has about 51 km of Gulf shoreline which is used heavily for recreation. About 16 km of the Gulf shore of the city of Galveston is protected by a massive concrete seawall. Most private property along the seawall is highly developed with hotels, motels, apartments, restaurants, tourist attractions and other businesses. The north portion of the city of Galveston and the south shore of nearby Pelican Island are occupied by marine and industrial facilities related to fishing, shipping and offshore oil exploration. The area is rapidly changing from sparsely settled grazing lands to subdivisions for summer and permanent homes. Follet's Island, west of San Luis Pass, is about 15 km long and is occupied by many permanent and summer homes.

Shoreline segments 112-124: The shores of this most easterly zone are mostly undeveloped. Within the city limits of Port Arthur on the northwest shore of Sabine Lake, there are some recreational developments principally for boating and boat racing. Two small towns are located near the Gulf, south of Port Arthur. The westerly portion of the Gulf shore is used extensively for public recreation, although virtually no facilities have been provided for public use of access.

Louisiana

Forty-five percent of the State of Louisiana consists of coastal and floodplain wetlands (Louisiana Planning Corporation, 1972, Vol. 1, pp. 235-236). Of the 12 million hectares of estuarine water and wetlands nationally, Louisiana has over 2.8 million hectares—more than any other state. These wetlands are primarily located in the Mississippi River Valley. The coastal marsh zone occupies a broad band of land from the State's Texas to Mississippi borders along the Gulf of Mexico (central Gulf, visual 5, Vol. 3). In these wetlands, and in the remainder of the coastal zone, lie the majority of Louisiana's people and industry. The activities of the people, their work and play, are closely tied to the use of the resources of the coastal zone (Louisiana Adv. Comm. Coastal Mar. Res., 1973a, p. 19).

The wetlands contain 80 percent of the manufacturing and some of the most valuable mineral resources of the region and of the United States. Large quantities of petroleum, natural gas, sulphur and salt are extracted. Together, activities of coastal and marine-related businesses provide more than 50 percent of Louisiana's tax revenues. Eighty percent of the State's population is located within the wetlands.

Opportunities for development offered by the Louisiana coastal area include the presence of rich oil and gas resources, agricultural lands, wildlife resources which support trapping and recreational activities, valuable fishery resources, and the proximity of the Mississippi River which serves as an important transportation route. These

opportunities have given rise to industrial, urban and agricultural development, which in turn have supported population increases.

Table G-2 indicates the land use in coastal Louisiana by acres. It can be seen that marshlands comprise 63 percent of the land area of the coastal parishes. These marshlands are essential habitat for numerous economically important species of fish and wildlife and are the site of wildlife refuges and game management areas.

The following discussion will cover the major components of the environment and their condition as they presently exist in the coastal zone. This discussion relies heavily on the work conducted at the Center for Wetland Resources at Louisiana State University (Gagliano, 1972) and the Atlas of Louisiana, Miscellaneous Publication 72-1 (Newton, 1972).

Barrier Islands, Reefs and Gulf Shore Areas

These areas represent the first line of defense against storms and marine processes, regulating inflow and outflow of Gulf waters, are valuable as wildlife habitats and recreation areas. They are vulnerable to erosion and hurricane damage.

Barrier islands, reefs and gulf shore areas extend along the entire Louisiana coast except for that part of the Mississippi Delta lying seaward of a line extending southwest of Breton Island.

There are two towns lying in this zone, Cameron in Southwest Louisiana, and Grand Isle in the Southeast. This zone also supports numerous but isolated fishing and trapping camps.

Fresh, Intermediate, Brackish and Saline Marsh Areas

These areas are extremely important as habitat for fish and wildlife, are an important component of the estuarine zones, are important recreational areas, and serve as buffer zones against storm generated surges.

Marsh areas extend along the entire coastline of Louisiana. They lie behind the barrier islands, reefs and gulf shore areas, or front directly on the Gulf as along the outer parts of the Mississippi delta.

This area is used extensively for hunting, fishing and trapping, and supports many isolated base camps.

Estuarine Nursery Areas

These areas are the most biologically productive areas of the state, essential to the fisheries, and provide habitat for wildlife. This zone supports an extensive commercial as well as sport fisheries, the nature of which is more extensively discussed in other appropriate sections.

Ocean Dumping Areas and Military Use

Ocean Dumping

Ocean dumping under the 1972 Marine Protection Research and Sanctuaries Act is regulated by permits issued by the United States Environmental Protection Agency. In May, 1973, a list of approved interim dumping sites was published in the Federal Register. Table G-3 shows those approved interim sites located in the Gulf of Mexico.

To date, two permits have been issued for dumping of industrial chemical wastes; one to Texas Shell Chemical Company and another to Louisiana Ethyl Corporation. An additional site was cleared for incineration of chemical wastes by Shell Chemical Company. The geographic coordinates of these three sites are as follows:

Texas Shell Chemical Company—27°12′ N - 27°28′ N; 92°28′ W - 94°44′ W (812,160 Ac)

Louisiana Ethyl Corporation—28°00′ N - 28°10′ N; 89°15′ W - 89°30′ W (86,400 Ac)

Shell Chemical Company (Incineration Site)—26°20′ N - 27°00′ N; 93°20′ W - 94°00′ W (823,680 Ac)

Military uses of the Continental Shelf

The Gulf of Mexico is used rather extensively by the Navy and Air Force for conducting military training, testing and research activities. These current activities consist of missile testing, ordnance testing, drone recovery operations, pilot training and electronic counter measure (ECM) activities by the Air Force. Mine research activities are conducted by the Department of Navy. Most of this activity takes place in areas designated for these purposes. However, live ordnance testing by the Air Force occasionally involves emergency release of ordnance outside designated bombing areas. These ordnances range from small munitions to 544 kg pound bombs. The possibility of occurrence of unexploded munitions on the ocean floor in the proposed sale area is not remote in certain locations. Potential for interference with military training and testing activities and possible hazards of unexploded munitions are discussed below.

Table G-2 Land Use in Coastal Louisiana
(No. of Acres)

Parish	Total Area	Water Area	Marsh-land	Forest Land	Agri. Land	Urban Land	Trans-port	Aggre-gate Land Ar.	Unac- 4/ counted Acreage	Area Percent
Cameron	1,087,360	194,101	739,474	-	269,492	180	2,332	1,011,478	-118,219	-10.9
Iberia	414,080	49,050	115,164	115,000	129,618	5,210	4,805	369,797	-4,767	-1.2
Jefferson	382,720	136,960	157,237	-	7,379	24,030	2,838	191,484	54,276	14.2
Lafourche	865,920	168,239	390,742	156,000	179,339	3,320	3,884	733,285	-35,604	-4.1
Orleans	232,320	112,460	59,930	-	1,055	37,995	30,941	129,921	-10,061	-4.3
Plaquemines	895,360	322,788	494,101	-	53,658	4,515	2,321	554,595	17,977	2.0
St. Bernard	517,120	220,915	275,499	-	11,838	3,065	609	291,011	5,194	1.0
St. Mary	453,760	87,147	172,308	143,000	107,276	5,440	3,549	431,573	-64,960	-14.3
Terrebonne	1,144,320	314,883	621,118	122,400	73,183	5,730	5,027	827,458	1,979	0.2
Vermilion	844,800	79,927	402,807	31,600	372,439	3,520	8,214	818,580	-53,707	-6.4
Totals	6,837,760	1,686,479	3,428,380	568,000	1,205,277	93,005	64,520	5,359,182		
% of land in study area by type			63%	10.6%	22%	1.7%	1.2%	100%		

*Note 1/: Total area less water area = land area. Land area less the aggregated areas of marshland, forest land, agricultural land, urban land and transportation land = unaccounted area. The result may be either positive or negative.

Source: State of Louisiana, 1967. A summary of preliminary findings concerning the Louisiana State Plan. La. Department of Public Works, Baton Rouge.

Table G-3

Approved Interim Dumping Sites - EPA Region VI

Location	Size (Square miles)	Depth (Feet)	Primary Use
Calcasieu Pass, Area A 29°45', 93°21'	1.00	6+	Dredged materials
Calcasieu Pass, Area B 29°45', 93°20'	1.00	6+	Do.
Calcasieu Pass, Area C 29°42', 93°21'	5.00	18+	Do.
Calcasieu Pass, Area D 29°35', 93°17'	5.00	18+	Do.
Southwest Pass 28°52', 89°31'	2.00	45+	Do.
Waste Disposal Area 27°44', 94°44', 27°28', 94°28'	16 mi. by 16 mi.	2,400	Chemical wastes
Waste Disposal Area 28°0', 28°20', 89°15', 89°35'	20 mil by 20 mi.	2,400+	Do.
Off Sabine Pass, Tex., Area A 29°37', 93°50'	Approx. 5	24	Dredged materials

continued

Table G-3 (continued)

Approved Interim Dumping Sites - EPA Region VI

Location	Size (Square miles)	Depth (Feet)	Primary Use
Off Sabine Pass, Tex., Area B 29°37', 93°48'	Approx. 3	30	Do.
Off Sabine Pass, Tex., Area C 29°40', 93°51'	Approx. 4	6	Do.
Off Galveston, Tex., Area A 29°19', 94°40'	Approx. 2.5	36	Do.
Off Galveston, Tex., Area B 29°20', 94°39'	Approx. 2.5	30	Do.
Off Galveston, Tex., Area C 29°17', 94°40'	Approx. 7	36	Do.
Off Galveston, Tex., Area D 29°22', 94°43'	Approx. 8	12	Do.

Source: Federal Register, Vol. 38, No. 94, Wednesday, May 16, 1973

The Navy has conducted no munitions dumping in water less than 914 meters in depth since 1945. Additional information received from the Office of the Oceanographer of the Navy are located off the Atlantic and Pacific coasts and no sites are utilized in the Gulf of Mexico.

The Air Force owns or leases approximately 20,235 hectares on Matagorda Island which were used for a variety of military purposes. All of this property has been determined to be in excess of the requirements of the DOD. Disposal of this property has been cleared with the Congressional Armed Services Committees and a Report of Excess is being prepared for forwarding to the GSA. All military uses of this property ceased as of June 30, 1975. Action is currently underway to clear the property of unexploded ordnance residue (U.S. Department of Defense, 1975).

Previously a coordinated fish and wildlife management plan was instituted on those lands under Air Force administration which were not intensively used to support military activities. The management purpose was to provide protection for rare and endangered species and non-game species and to provide recreation through hunting and fishing.

Recreation and Allied Resources

The northern Gulf of Mexico coastal zone is one of the major recreational areas of the U.S. particularly in connection with salt-water fishing and beach-oriented activities.

There is considerable diversity in natural landscapes from the semi-arid beaches of south Texas through the marshes of Louisiana. Large numbers of visitors are attracted from outside the region by these natural conditions, as well as the subtropic climate.

In Louisiana, inaccessibility of the coastal marshlands to automobile travelers has limited the development of recreational facilities to a few areas. However, the vast marshlands provide abundant game and fish which attract sport fishermen and hunters.

Public parks and preserves provide opportunities for hunting, fishing, camping, wildlife viewing and photography. Commercial recreational facilities are also very important as well, and include ornamental gardens, marinas and a variety of resorts and services.

The long and colorful history of the Gulf South has provided a rich legacy in architectural forms, historic sites and historic districts. The prehistoric record of archaeological remains in this area is also large and continually expanding through discovery and research.

Sport Fishing

Limited access to fishing areas has precluded full utilization of the sport fishery resources but man-days effort and pounds of catch are impressive. A salt-water angling survey conducted by the National Marine Fisheries Service in 1970 provides the most recent comprehensive sport fishing statistics for the Gulf of Mexico (Deuel, 1973). Visual No. 5 for each of the western, central and eastern Gulf areas displays coastal zone and offshore fisheries. Also of interest in this connection will be Visual No. 4 showing undersea features.

Table G-4 illustrates the number of salt-water anglers and their catch in the western Gulf of Mexico and its relationship to the total United States catch for 1970. Table G-5 illustrates the salt-water fishermen and their catch for the western Gulf of Mexico for 1970.

Detailed information on sport fishing activity, catch and value is not uniformly available for the Gulf of Mexico, although research is underway which should improve this situation soon. The National Marine Fisheries Service has established two sport fishing laboratories in the Gulf area and has undertaken with their port sampling of commercial products the gathering of sport fishing data. A number of sport fishing studies are underway in Texas bays by the Texas Parks and Wildlife Department and the University of Texas. Also, in 1975, the National Marine Fisheries Service began a creel census of salt-water fishing along the south Texas coast.

Party boat fishing is characterized by the use of a large boat in the range of 17 to 20 meters carrying a large number of people. Bottom fishing consumes the majority of fishing time, although less often drift fishing and trolling methods are used. Party boats usually charge a set fee per person (per "head") and may require a certain minimum number of passengers aboard before they make a trip.

Charter boat fishing is characterized by the use of a smaller boat, about 10 to 14 meters in length, carrying up to 6 or 8 persons. Trolling is the primary method used.

Table G-4 Estimated Number of Salt-Water Anglers & Their Catches in the West Gulf Coast of Mexico & Relationship to the Total U. S. Catch for 1970.

	No. of Anglers (Thousands)	% of U.S. Total	No. of Fish Caught	% of U.S. Total	Weight of Fish Caught	% of U.S. Total
West Gulf of Mexico (Miss. River to Texas)	872	9	97,708	12	151,608	10
Total U.S.	9,392		817,317		1,576,823	

Source: Dept. of Commerce, National Marine Fisheries Service
Fisheries of the United States, 1974

Table G-5

Salt-Water Fishermen and Their Catches[1/]
by Principal Area and Method of Fishing - 1970

Region	Ocean	Principal area of Fishing	Principal methods of fishing			
		Sounds, rivers, and bays	Private or rented boats	Party or chartered boats	Bridge, pier, or jetty	Beach or bank
	- - - Thousands - - -					
est Gulf of Mexico:						
Number of fishermen...	341	477	284	101	288	198
Number of fish caught.	47,173	50,535	56,684	4,425	23,236	13,363
Total weight.........	64,800	86,808	85,505	8,579	33,024	24,200

1/ The number of fish caught and the weight of fish caught in the two principal areas of fishing are equal to the total catch for a region, and the number and weight caught by the four methods of fishing are equal to the total catch for a region. However, the number of anglers is not additive as some anglers fished in both areas and by more than one method for certain species groups in a particular region.

Source: Deuel, 1973

It is estimated that approximately 80% of all fishing activity occurs within 12 miles (20 km) of shore (U.S. Dept. of Commerce, 1973b). A further rationale for the location of this 12 mile (20 km) line was the consideration of the maximum distance a party or charter boat can travel and return to shore in one day and allow adequate time for fishing in place of anchor.

Louisiana: Sport fishing in Louisiana is a very popular form of recreation. Coastal marshlands with few roads reaching the shoreline has limited fishing access and precluded full utilization of the salt-water fishery resources. Nevertheless, man-days of fishing effort and pounds of catch are impressive. The data used here to portray the intensity of use of Louisiana's sport fishing resource is based on an unpublished report of the results of a telephone survey of 2,270 Louisiana households by the Bureau of Sport Fisheries and Wildlife. The study area was divided into nine hydrologic sub-basins as described in Table G-6 and portrayed in Figure G-5. Data is for the 1968 season.

Table G-7 gives man-days and pounds of catch by sub-basin and type of fishing activity. Included are both freshwater and saltwater sport fishing. From this table the success or pounds per man-day effort can be derived. In order of yield, Sub-basin III ranks first with II, VII, I, IV, and VI in descending order. The average for all sub-basins is 4 kg per man-day of fishing effort.

As indicated on Table G-7, saltwater finfishing activities are most concentrated in Sub-basin I and IV. Some of the more popular saltwater sport fish are croaker, red drum, sea trout, flounder, tarpon, snappers and groupers.

Freshwater finfishing activity is concentrated in Sub-basin IV which corresponds to the Atchafalaya River basin. Popular freshwater sport fish include largemouth bass, bluegill, redear, crappie and catfish.

Surf-fishing is popular along the barrier islands of coastal Louisiana, however, most of these islands are accessible only by boat. Sport fishing around offshore oil and gas rigs is also popular. Therefore, the large number of man-days spent in sport fishing indicates a corresponding high level of boating activity. It can be assumed that the highest levels of recreational boating related to sport fishing will be found in Sub-basins I and IV where the most sport fishing activity is concentrated currently. In September, 1970, there were 101,084 registered boats over twelve parishes of Louisiana (Jones and Rile, 1972). This figure includes commercial vessels, but the greatest portion are private recreational boats.

Texas: The Texas coastal zone, with its immense expanse of shallow bays and beaches accessible to the average man, furnishes an excellent region for the sport fisherman to pursue his avocation. Based upon data generated between 1968 and 1970 the Texas Parks and Wildlife Comprehensive Planning Board ranks fishing as the number one recreational activity in the coastal region of Texas in terms of activity days of participation.

Fishing, with a total of 12,051,800 activity days recorded, was followed by swimming (4,437,100), boating (3,350,000), camping (3,302,900) and picnicking (2,294,700) (Texas Parks & Wildlife Dept., 1974). Table G-8 shows saltwater based activities occurring in the same region but excluding those occurring within urban limits. Fishing again stands out with nearly 6.5 million activity days.

Quantification of saltwater sport fish catch for Texas proved difficult because no comprehensive surveys have been conducted. Creel census data were available for some of the coastal embayments; however, these were not recent and were limited to short time periods (Table G-9). Based on existing data from the National Marine Fisheries Service 1970 Saltwater Angling Survey (Deuel, 1973) and an unpublished report from the U.S. Fish and Wildlife Service, as well as data from the Texas Parks and Wildlife Department, it was possible to extrapolate and arrive at a gross estimate of the total saltwater sport fish catch as well as an average catch per activity day. It must be stressed that the data available from the estimates which were made, represent different years, different research procedures and different geographic areas, leaving a large margin for error. Even though the margin for error is great, the estimates are felt to be within an acceptable range of probability and represent the best data available.

According to the F&WS report, the total catch for Louisiana was estimated at 11 million kg, of which five million kg represented the catch east of the Mississippi River, thus leaving an estimated catch for Louisiana west of the Mississippi River of six million kg. The 1970 Angling Survey estimated the total saltwater sport fish catch in from this total, the new catch for Texas amounted to 63 million kg. According to the Texas Parks and

Table G-6 Hydrologic Sub-basins of the Louisiana Coast

Sub-basin	Area
I	The area between Pear River and Bayou Terre aux Boeuf including Lake Maurepas and Lake Pontchartrain.
II	The area between Bayou Terre aux Boeuf to the Mississippi River.
III	The active Mississippi River Delta south of Bayou Baptiste Coullette and Red Pass.
IV	The area between the Mississippi and Bayou Lafourche.
V	The area between Bayou Lafourche and the Atchafalaya River.
VI	The area between the Atchafalaya River and Bayou Sale.
VII	The area between Bayou Sale and along the drainage basin line in the vicinity of Freshwater Bayou and northward to Abbeville and Lafayette.
VIII	The area between Freshwater Bayou and the eastern drainage basin for the Calcasieu. This line approximates the line formed by State Highway 27 and north to Iowa, Louisiana.
IX	The area of the Calcasieu and Sabine drainage basins.

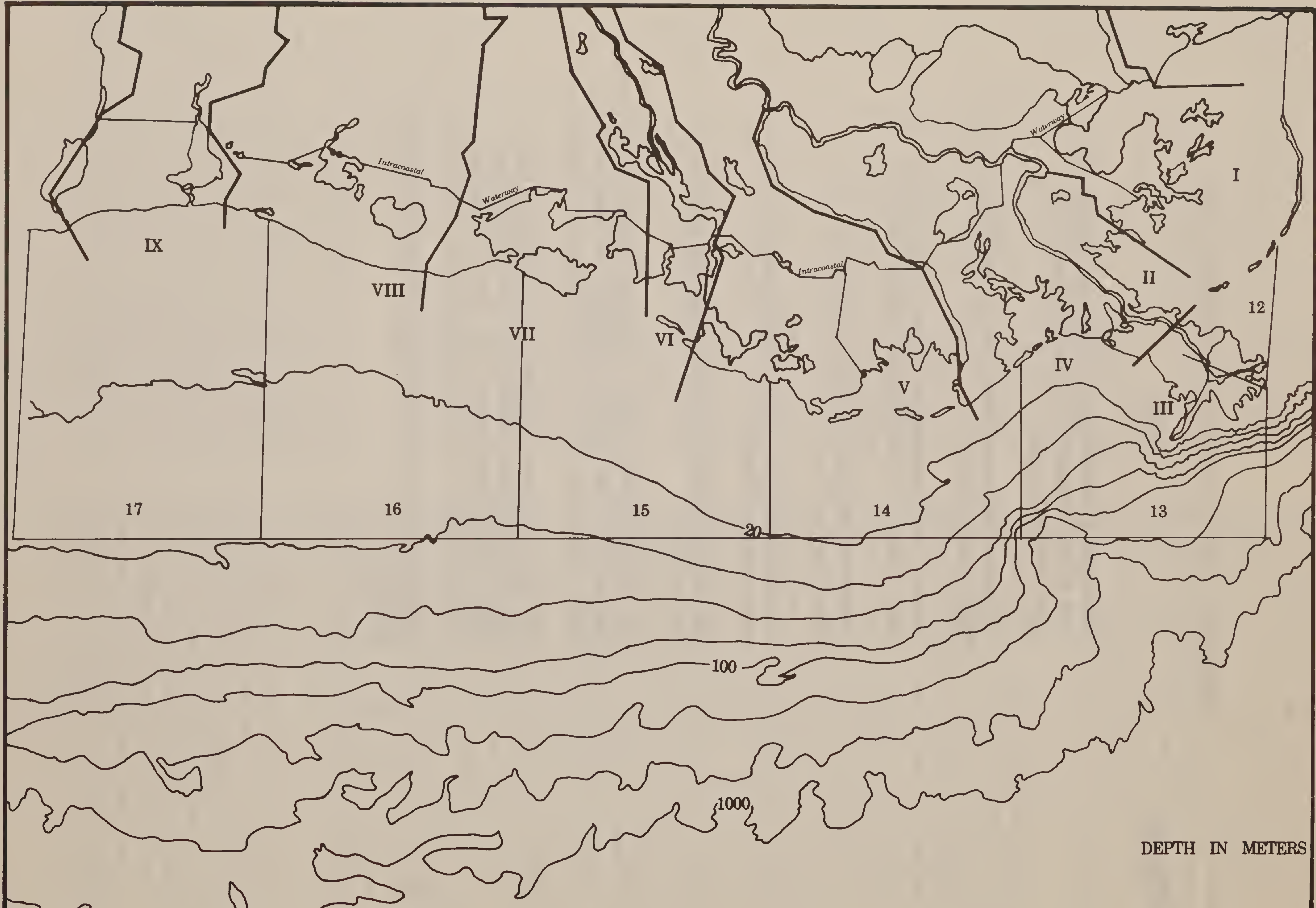


Figure G-5 Coastal zone of the Louisiana coast showing nine Subbasins (Hydrologic Units I-IX) and Offshore Shrimp Fishing Grid Zones (Zones 12-17). (Modified from Lindell et al. 1972).

Table G-7 1968 Sport Fishing - Louisiana

ACTIVITY

	SPORT FINFISHING SALTWATER	SPORT FINFISHING FRESHWATER	SPORT CRABBING	SPORT CRAYFISHING	SPORT SHRIMPING	TOTALS
SUB-BASIN I						
MAN-DAYS	1,730,000	768,000	172,000	21,000	60,000	3,751,000
POUNDS	10,380,000	1,536,000	15,236,000	105,000	3,000,000	30,257,000
SUB-BASIN II						
MAN-DAYS	101,000	26,000	27,000	9,000	18,000	181,000
POUNDS	606,000	52,000	351,000	45,000	900,000	1,954,000
SUB-BASIN III						
MAN-DAYS	39,000	18,000	3,000	*-----	18,000	78,000
POUNDS	234,000	45,000	39,000	*-----	900,000	1,218,000
SUB-BASIN IV						
MAN-DAYS	1,063,000	490,000	497,000	50,000	98,000	2,198,000
POUNDS	6,378,000	980,000	6,461,000	250,000	4,900,000	18,969,000
SUB-BASIN V						
MAN-DAYS	570,000	391,000	115,000	24,000	63,000	1,163,000
POUNDS	3,420,000	782,000	1,495,000	120,000	3,150,000	8,967,000
SUB-BASIN VI						
MAN-DAYS	63,000	1,653,000	58,000	307,000	4,000	2,085,000
POUNDS	378,000	3,306,000	754,000	1,535,000	200,000	6,173,000
SUB-BASIN VII						
MAN-DAYS	185,000	192,000	61,000	31,000	49,000	518,000
POUNDS	1,110,000	384,000	793,000	155,000	2,450,000	4,892,000

* NO HABITAT AVAILABLE

Table G-7 (continued) 1968 Sport Fishing - Louisiana

ACTIVITY

	SPORT FINFISHING SALTWATER	SPORT FINFISHING FRESHWATER	SPORT CRABBING	SPORT CRAYFISHING	SPORT SHRIMPING	TOTAL
SUB-BASIN VIII						
MAN-DAYS	72,000	487,000	56,000	74,000	22,000	711,000
POUNDS	432,000	974,000	728,000	370,000	1,100,000	3,604,000
SUB-BASIN IX						
MAN-DAYS	222,000	229,000	261,000	20,000	41,000	773,000
POUNDS	1,332,000	458,000	3,393,000	100,000	2,050,000	7,333,000
TOTALS						
MAN-DAYS	4,045,000	4,254,000	2,250,000	536,000	373,000	11,458,000
POUNDS	24,270,000	8,517,000	29,250,000	2,680,000	18,650,000	83,367,000

Source: Data from unpublished report by Bureau of Sport Fisheries and Wildlife, 1968.

Table G-8 Total Participation in Saltwater Activities Occurring In Rural Areas Within Texas Gulf Coast Regions (Activity Days)

Activity	REGION 27	25	28	24	33	34	Total
Saltwater Boating	125,258	8,914	640,644	26,480	465,408	95,821	1,362,525
Saltwater Fishing	220,654	296,427	2,770,958	126,169	2,518,885	565,357	6,498,450
Faltwater Skiing	-0-	1,740	97,921	11,538	33,592	8,048	152,839
Surfing	-0-	3,031	206,353	-0-	89,053	40,184	338,621
TOTAL	345,912	310,112	3,715,876	164,187	3,106,938	709,410	8,352,435

Source: Texas Household Demand Survey, 1968, Texas Parks and Wildlife Department, Comprehensive Planning Branch

Table G-9 Listings of General Creel Census Data [1/] for Three Texas Coastal Areas

Census Study	Fish Caught/man hr.	Lbs. of Fish Caught/man hr.	Major Species
Lower Laguna Madre Area, 1959-1960	.99	1.15	Speckled Trout
San Antonio Bay Area, Summer, 1962	.55	.46	Not Available
Galveston and Trinity Bay Area, 1963-1964	1.62	1.29	Sand Trout Croaker Speckled Trout

1/ Data taken from three different studies. Data was obtained during the summer only in the San Antonio Bay area and catch figures are low as compared to other data due to high participation of tourists.

Source: Creel Census Reports - Texas Parks and Wildlife Department

Wildlife Department's 1968 Household Demand Survey, a total of 6,498,450 activity days were expended in saltwater sport fishing. Using these data, the average catch per activity day was calculated to be 10 kg for Texas. By combining the F&WS data for Louisiana (man days activity in saltwater sport fishing) and the data for Texas, an average catch per activity day for the western Gulf was calculated at nine kg.

Although the sport fishing effort for Texas seems disproportionately high in comparison with Louisiana, when the factor of accessibility to the coastal areas is considered, the reason for the difference becomes more apparent. Much of the Louisiana coast is inaccessible and, because of the isolation, the sport fishing activity is much less than along the Texas coast, most of which is accessible. Additionally, pier fishing is extremely popular along the Texas coast, a type of fishing limited to a few isolated locations along the Louisiana coast. Although sport fishing is an extremely popular recreational activity in coastal Louisiana, offshore saltwater sport fishing is a pursuit enjoyed by a more affluent group because ownership of a boat is almost a necessity for the Louisiana saltwater sport fisherman.

Data from the 1970 Angling Survey estimated a total of 872,000 sport fishermen were involved in the saltwater sport fishing effort in the western Gulf. These fishermen caught 69 million kg which would give an average yearly catch of 79 kg per fisherman. The number of fish caught was estimated to be 97,708,000, yielding an average weight per fish of 0.7 kg.

Tables G-10 and G-11, from the 1970 Saltwater Angling Survey (Deuel, 1973) provide detail of the methods of fishing, species of fish caught, their weight and numbers caught in the western Gulf of Mexico.

Big game fishing: Big game fish (also referred to as billfish) are sought in deep water and at considerable distance from shore.

Based on three years of data collection, Luis R. Rivas of the National Marine Fisheries Service made the following comments about the billfish sport fishery of the northern Gulf of Mexico.

During the season (April through October) the fishing effort expended on billfishing amounts to an annual average of 11,756 hours of trolling equivalent to 1,680 boat days. It takes, on the average, 18 fishing days to boat a blue marlin, seven to boat a white, and six to boat a sailfish. Therefore, in 18 days of trolling, it is possible to boat one blue, two whites, and three sails for a total of six billfish, or an average of one fish per three days of trolling. On the average, 657 billfishes weighing a total of 25,303 kg are caught every year. An average of 103 blue marlin weighing a total of 12,988 kg are caught by anglers every year. On the average, 252 white marlin weighing a total of 6,205 kg and 302 sailfish weighing a total of 6,027 kg are caught every year.

In the northern Gulf, the catch-per-unit-of-effort by the sport fishery, for all three species of billfishes combined, was 0.063 fish per hour of trolling in 1971, 0.041 in 1972, and 0.036 in 1973.

Trolling for billfishes is conducted above the continental shelf from about 55 m outward and also above the continental slope at depths of up to 914 meters. Distance from shore varies from as little as 20 km, off the mouth of the Mississippi River, to 97 km or more off the Clearwater-St. Petersburg area of Florida. The most important billfishing ports in the Gulf, from west to east, are Port Isabel, Port Aransas, Rockport and Port O'Connor in Texas.

The billfish sport fishery was practically nonexistent in the Gulf until about 20 years ago. Pioneered by the New Orleans Big Game Fishing Club, it has grown tremendously since its inception and it still continues to grow.

Artificial reefs: In recent years, the establishment of artificial reefs has become popular in the Gulf of Mexico. These artificial reefs made of old car bodies, tires, concrete pipes, ships, rubble and numerous other materials provide additional surface area of hard substrate on which numerous types of algae and invertebrate species may grow. These organisms are available as food for foraging species which in turn, attract predatory fishes. In addition to the expanded food chain and tropic food level potentials, the artificial reefs serve as refuge, protection and orientation sites. These new sites by attracting and concentrating fish species improve fishing success. However, the population size of fish species are not necessarily increased.

The Texas Coastal and Marine Council has acquired 12 Liberty Ships to use as offshore artificial reefs. Four locations have been selected, each of which will be a site for establishing a reef by sinking of three stripped-down Liberty Ships. The reefs, will be from about 20 to 55 km from

Table G-10 Number of Fish Caught by Saltwater Anglers in 1970 in the Western Gulf of Mexico by Species and by Principal Area and Method of Fishing. (Thousands)

	Principal Area of Fishing		Principal Method of Fishing			
Species	Ocean	Sounds Rivers & Bays	Private or Rented Boats	Party or Charter Boats	Bridge Piers or Jetty	Beach or Bank
Catfish	3,083	12,307	4,512	725	7,661	2,492
Croakers	5,476	8,417	3,384	892	6,237	3,380
Drum, Black	724	4,363	4,435	16	457	179
Drum, Red	2,366	3,545	4,131	47	418	1,315
Flounders, Summer	984	1,192	1,714	124	185	153
Grunts	11,805	20	11,555	-	270	-
Kingfish	2,712	531	541	163	2,279	260
Porgies	470	1,498	1,107	163	225	473
Sea Trout, Sand	5,282	2,907	5,645	450	1,515	579
Sea Trout, Spotted	11,185	13,113	17,615	985	2,599	3,099
Snappers	1,047	168	537	390	288	-

TABLE G-11

SALTWATER SPORTFISHING EFFORT IN THE WESTERN GULF OF MEXICO* BY SPECIES GROUP, NUMBER OF FISH CAUGHT, NUMBER OF ANGLERS, AND ESTIMATED WEIGHT OF CATCH.

Species Group	Number of Fish Caught (000)	Number of Anglers (000)	Estimated Weights (000)
Basses	12	4	24
Bluefish	477	24	1,308
Bonitos	12	6	37
Catfishes	15,390	279	17,800
Cobia	85	3	43
Croakers	13,893	403	14,743
Drum, Black	5,087	185	13,004
Drum, Red	5,911	302	25,520
Eel, American	17	17	19
Flounders, Summer	2,176	211	2,985
Groupers	438	40	922
Grunts	11,825	32	4,316
Jacks	145	40	1,223
Kingfishes	3,243	90	3,107
Mackerels, King	259	39	2,978
Mackerels, Spanish	479	31	608
Mullets	257	16	95
Perches	688	58	584
Pompanos	135	45	179
Porgies	1,968	164	5,675
Puffers	25	12	8
Sea Robins	4	4	1
Sea Trout, Sand	8,189	200	9,345
Sea Trout, Spotted	24,298	406	40,487
Sharks	68	12	1,167
Sharks, Dogfish	58	25	54
Skates and Rays	271	29	1,603
Snappers	1,215	49	2,554
Snappers, Red	119	12	278
Spadefish, Atlantic	190	30	283
Miscellaneous	774	45	658
Total	97,708	**	151,608

* The Western Gulf includes the area between the mouth of the Mississippi River and the Mexican border.

** The number of anglers is not additive because of duplication of anglers among species groups.

Source: Deuel, 1973.

shore to make them accessible to sport fishermen and divers. However, they will be in water at least 24 meters deep in order to allow 15 meters of clearance above the ships which, when stripped, will be about 9 meters high. Three ships have been placed in Block 1070, South Padre Island near Port Mansfield and one ship has been sunk in Block 802, Mustang Island. Two additional ships are ready for sinking and others are in various stages of preparation.

Recreational boating

A 1973 National Marine Fisheries Service study provides a general overview of recreational boating in the U.S. and its subdivisions, including the states bordering the Gulf of Mexico. As of October 1973 there were 8,008,000 privately owned recreational fishing boats in the U.S. (Ridley, 1975) and some 1,010,000 of these boats were used in saltwater recreational fishing activities. It was further estimated that commercial recreation fishing boats in the U.S. numbered 2,496. Table G-12 provides more detail data for the Gulf of Mexico Region. In this region 349,000 private recreation boats were used in saltwater. Most of these boats were under 26 feet (8 meters) in length. There were also 473 commercial recreational fishing boats, predominantly in the 40′ - 65′ (12-20 meters) length class.

Recreational boating activity is also high in the central Gulf coast area as indicated by saltwater fishing activity.

As previously mentioned, in 1970 there were 101,084 boats of all types over 12 feet (3.7 meters) in length registered in coastal parishes of Louisiana.

In Texas the use of boats for fishing and for a variety of other recreational activities is increasing rapidly. Data compiled by the Texas Parks and Wildlife Department between November 1970 and November 1973 show that the total boat registration in the 17 Texas Coastal Counties increased 60.6 percent (from 73,393 to 121,124). The top ten coastal counties accounted for approximately 28 percent of all boats registered in Texas during this period.

Population and public access to water seem to be the major factors bearing on boat numbers. Harris County has the largest population and by far the largest number of boats registered in the coastal zone. In general, the counties with high boat registration have access to a large amount of bay and ocean frontage. However, Harris, Orange and San Patricio Counties have no open ocean frontage and relatively little bay frontage, but they do have water access to the ocean and a great deal of fresh water located in or near their boundaries.

The importance of these boats for outdoor recreation is indicated by over 96 percent of those registered in this area in 1973 being classified as "pleasure use" craft. Table G-13 illustrates the top ten coastal counties in boat registrations for Texas.

Hunting

Hunting is one of the higher ranking outdoor recreational activities in the Central Gulf area. Important mammals include deer, squirrels, rabbits and occasionally raccoons. Upland birds include quail, dove, turkey and a variety of water fowl are taken in the marshes and coastal water areas.

Hunting effort for coastal Louisiana by species and sub-basin is portrayed in Table G-14. For the entire zone, rabbits rank first and ducks a close second. A more detailed discussion of Louisiana hunting may be found in Final Environmental Statement, OCS Sale No. 36.

Outdoor Recreation Areas

Included under this heading are federal and state wildlife refuges, game management areas, state parks, beaches used for recreation, ornamental garden, and historical and archaeological sites. These are portrayed on Visual No. 1.

A proposal to establish a wilderness area comprising 6ll hectares of Horn and Petit Bois Islands is now under consideration by the National Park Service. Another 1,036 hectares are considered potential for later addition to the wilderness area.

Chalmette National Historical Park was the scene of the Battle of New Orleans in the War of 1812. This 55 hectare park includes the inactive Chalmette National Cemetery and received 195,000 visits in 1974.

Padre Island National Seashore occupies 54,420 hectares of Padre Island extending 129 km along the south Texas shore from Corpus Christi to near the mouth of the Rio Grande. Besides being one of the last natural seashores in the nation, Padre Island is a wintering area for migratory waterfowl. The island offers numerous recreational activities including swimming, camping, surfing, surf fishing, hiking, birdwatching,

Table G-12 Recreational Boating Activity in States Bordering the Gulf of Mexico
November, 1972 - October, 1973

	Less than 16'	16-26'	Greater than 26'	Total
Estimated No. of Private Recreational Boats	988,000	389,000	31,000	1,408,000
No. of Private Recreational Boats that Fished in Saltwater	190,000	141,000	18,000	349,000
	Less than 40'	**40-65'**	**Greater than 65'**	**All Classes**
Estimated No. of Commercial Recreational Fishing Boats	85	310	42	473

Major Species of Fish Sought By:	Open Ocean	Rivers, Sound, and Bays
Private Recreational Boaters	Groupers, Red Snappers, Trouts, Snook	Spotted Sea Trout, Red Drum, Snappers
Fishermen on Commercial Recreation Boats	Red Snappers, Snappers, Groupers, King Mackerel, Kingfishes	Red, Snapper, Spotted Sea Trout, Sand Sea Trout

Source: Ridgely, 1975.

Table G-13

Top Ten Texas Coastal Counties In Boat Registration
1970 - 1973

1970 Rank	1970 County	1970 No. of Boats Registered	1973 County	1973 No. of Boats Registered
1	Harris	39,819	Harris	66,436
2	Jefferson	7,904	Jefferson	14,809
3	Galveston	4,935	Galveston	7,482
4	Nueces	4,908	Nueces	7,158
5	Brazoria	3,699	Orange	6,947
6	Orange	3,604	Brazoria	6,530
7	Cameron	1,538	San Patricio	2,389
8	San Patricio	1,524	Cameron	2,261
9	Calhoun	1,191	Matagorda	1,559
10	Matagorda	1,075	Calhoun	1,476
	TOTAL	70,197	TOTAL	117,047

Source: Boat Registration Division, Revenue Branch, Texas Parks and Wildlife Departments, 1974.

Table G-14

Hunting Effort in Coastal Louisiana
(Data in man-days x 1000 during 1968-69 season)

Sub-Basin	Squirrels	Rabbits	Quail & Dove	Other Small Game	Deer & Turkeys	Duck	Geese	Other Marsh Birds
I	29.4	68.5	18.5	2.2	17.6	66.0	6.6	1.9
II	0	0	0	0	1.2	3.9	0	0
III	0	0	0	0	0	12.0	6.0	8.8
IV	31.2	108.0	5.6	0	3.5	68.7	0	16.4
V	43.0	131.6	17.5	0	6.4	64.0	5.1	4.6
VI	187.2	176.9	13.9	13.5	144.0	81.7	4.6	0
VII	50.3	92.4	133.1	12.6	48.7	82.9	17.8	4.7
VIII	55.3	59.4	58.0	1.3	15.4	140.4	54.8	0
IX	23.4	56.1	29.2	5.2	3.6	135.4	28.7	1.5
TOTALS	419.7	693.0	276.0	34.7	240.4	655.8	123.6	37.9

Unpublished Fish and Wildlife Service Telephone Survey

beachcombing, scuba diving and sunbathing. In 1974, Padre Island National Seashore received 842,700 visits.

National natural landmarks: The National Park Service administers the National Landmarks program. The objective of this program is to assist in the preservation of natural areas which will illustrate the diversity of the country's natural history. Registration of a site as a Natural Landmark does not change its ownership. However, the owner of the site is required to preserve the natural character of the registered site in order to retain its registration as a Natural Landmark.

There are as yet no registered national natural landmarks in Louisiana and none in the coastal zone of Texas.

National wildlife refuges: The U.S. Fish and Wildlife Service of the U.S. Department of the Interior has the responsibility for ensuring the conservation of the country's wild birds, mammals and sport fish. The primary purposes of wildlife refuges are to provide sanctuaries for wildlife and fish by preserving breeding grounds and habitat which may be becoming scarce in other areas due to encroachment on natural habitats by agricultural, industrial and urban development, and to provide opportunities for the scientific study of various species of wildlife and for the management and preservation of their populations. These refuges also provide important opportunities for outdoor recreation, primarily nature study and natural scenery appreciation.

The Louisiana coastal zone contains five national wildlife refuges.

The Gulf Islands Refuge consist of Breton and Chandeleur Islands and was established October 1904 and contains 1,824 hectares. Many waterfowl and shore birds frequent the islands, and sea turtles nest on their shores. They may be reached only by water and there are no recreational facilities.

The Delta Refuge is on the east bank of the Mississippi River, 11 km below Venice and is accessible only by boat. The refuge contains 19,749 hectares. Thousands of blue and snow geese and many species of ducks arrive each fall from the northern breeding grounds to winter on the Delta marshes. Deer and fur-bearing animals are found in abundance. Alligators are seen frequently but are not abundant. Sport fishing is permitted.

Lacassine National Wildlife Refuge is located in southwest Louisiana. At this 12,856 hectare waterfowl wintering area one can see the largest concentration of white-fronted geese in the Mississippi Flyway and one of the larger populations of fulvous tree ducks in the United States. Part of the refuge is open to waterfowl hunting. A main attraction is a 6,475 hectare fresh water pool where sport fishing is permitted. Catahoula and Shell Keys National Wildlife Refuges are under the administration of Lacassine Refuge. Catahoula Refuge, established October 1958, contains 2,148 hectares. It is situated on the east end of the 10,522 hectare Catahoula Lake. Through agreement with the U.S. Army Corps of Engineers and the Louisiana Wildlife and Fisheries Commission, the Bureau manages water levels in the state owned lake. Established primarily as a sanctuary for wintering waterfowl but also for other species of wildlife, fishing and squirrel hunting are permitted. Shell Keys Refuge, established August 1907, is a 20 hectare colonial bird nesting island offshore in the Gulf of Mexico.

Also in southwest Louisiana is the Sabine National Wildlife Refuge. Established in December 1973, and located in Cameron Parish is a 57,809 hectare refuge. It includes three large artificial freshwater impoundments, and is bounded on the west and east by two large brackish lakes, Sabine and Calcasieu. Sabine provides a winter home for thousands of geese and ducks. Flocks of blue and snow geese may be seen feeding in the marshes adjacent to the highway. Sport fishing and waterfowl hunting are permitted. The wildlife trail in Pool 1B affords excellent opportunities for visitors in all seasons.

There are five national wildlife refuges on the Texas Gulf coast. The eastern most refuge, Anahuac, occupies 4,023 hectares on East Bay of Galveston Bay. The primary species for this refuge are: Lesser Canada, snow and blue geese, mottled ducks, masked ducks, canvasbacks and yellow rails. Rare and endangered species are alligators, bald eagles and peregrine falcons.

Brazoria National Wildlife Refuge contains 3,857 hectares of coastal marsh and prairies in Brazoria County. Three-fourths of the refuge is less than 1.2 meters in elevation, and spoil bank knolls and windbreak plantings are the only break in the marsh vegetation. The primary species of this refuge are: geese, ducks and muskrats and endangered species include alligators and red wolves. The refuge offers public hunting and fishing in limited areas, sightseeing, birdwatching and

nature photography. The refuge office, which also administers the San Bernard National Wildlife Refuge, is located in Angleton, Texas.

San Bernard National Wildlife Refuge, which was established in November of 1968, is Texas' newest wildlife refuge containing 6,038 hectares in Brazoria and Matagorda counties. The primary species for this refuge are: geese, ducks, wading birds, shorebirds and the endangered red wolf.

The Aransas National Wildlife Refuge occupies 22,190 hectares in Calhoun, Aransas and Refugio counties and is the largest on the Texas coast. This refuge is the wintering ground for the rare and endangered whooping crane. Other primary species include: sandhill cranes, roseate spoonbills, egrets, herons, peregrine falcons, geese, ducks, turkeys, shorebirds, deer, peccaries, caracaras, white-tailed hawks, Texas red wolves and alligators.

Texas' second largest wildlife refuge, Laguna Atacosa National Wildlife Refuge, occupies 18,272 hectares in Cameron County. Located 40 km northeast of San Benito, this refuge was established in March of 1946 to serve as a wintering and feeding Wildlife Refuge are: geese, ducks, herons, ibises, shorebirds, gulls, terns, doves, cranes, white-tailed hawks and whitetailed kites. The refuge offers a variety of habitat including coastal prairies, salt flats and low wooded ridges. Subtropical forms, such as the ocelot and the aguarundi, occur along with species from the northern latitudes. Tour roads, hiking trails, and blinds are provided for visitors to use in sightseeing, nature study and photography. Camping is permitted in designated areas, and saltwater fishing and boating are allowed in the Intracoastal Canal. A major portion of the Laguna Atascosa National Wildlife Refuge has been recommended for National Landmark recognition.

State wildlife refuges and management areas: Texas and Louisiana maintain wildlife management areas within the coastal zone. Their locations and approximate size can be determined from Visual No. 1.

Although management goals may differ somewhat between the states, these areas serve primarily to maintain habitat and breeding space for wildlife and to provide wildlife-oriented recreation under closely controlled conditions.

The State of Louisiana administers three wildlife refuges in coastal Louisiana.

Rockefeller Wildlife Refuge—33,185 hectares. It is a major wintering ground for blue and snow geese in the Mississippi Flyway. Mammals found here include muskrats, nutria, deer and rabbits. Extensive impoundments have been constructed to control and regulate water levels.

Louisiana State Wildlife Refuge—6,070 hectares. Species include numerous waterfowl, nutria, muskart and raccoon. Marsh Island Wildlife Refuge—31,971 hectares. It is an important wintering area for blue, snow and Canada geese and contains a large concentration of alligators.

The Texas Parks and Wildlife Department administers three state-owned wildlife management areas. They range from 3,401 to 203 hectares in size. The smallest, Las Palomas Wildlife Management,' is in extreme Texas and is divided into three separate small units.

Private wildlife refuges: The National Audubon Society manages the 10,587 hectare Paul J. Rainey Wildlife Refuge on the Louisiana coast as well as several tracts in the Texas coastal zone. Some of these are located near state or national wildlife refuges and serve to extend the sanctuary provided by these refuges.

Table G-15 lists the state wildlife management areas and preserves.

Table G-16 identifies the Audubon sanctuaries in Texas. They are located on Visual No. 1 for the western Gulf.

National and state parks: There is one National Park Service area located in Louisiana, the Chalmette National Historical Park, located on the site of the Battle of New Orleans.

State parks average much smaller in size than the wildlife areas previously discussed and are generally more activity oriented than the national parks. They are numerous and widely distributed along the Texas and Louisiana coast and serve a large number of people within their localities as well as significant numbers of regional and national visitors.

Collectively the state parks constitute a major part of the recreational resources of the region. Their number and diversity makes generalization difficult. Not only do they vary in size, but their activity and resource orientation varies from fishing causeways through intensively developed recreation sites to scientific, cultural and aesthetic themes.

Table G-17 lists the state parks found in Louisiana and Texas. Most of the Louisiana parks are

Table G-15 State Wildlife Management Areas and Preserves

Name of Area	County Location	Hectares
Louisiana		
Pearl River	St. Tammany (Parish)	10,812
St. Tammany	St. Tammany	526
Biloxi	St. Bernard	16,019
Bohemia	Plaquemines	6,475
Pass a Loutre	Plaquemines	26,710
Wisner	Lafourche	8,750
Salvador	St. Charles	11,129
Pointe au Chien	Lafourche	11,430
Bonnet Carre'	St. Charles	1,533
Thistlethwaite	St. Landry	4,492
West Bay	Allen	22,333
Sabine	Calcasieu	4,249
Texas		
J. D. Murphee	Jefferson	3,401
Sheldon	Harris	1,013
Las Palomas		283
Longoria Unit	Cameron	
Voshell Unit	Cameron	

Source: Louisiana State Parks and Recreation Commission , 1974.
Texas Parks and Wildlife Dept., 1974

Table G-16 National Audubon Society Sanctuaries in Texas

Name of Area	Hectares
Vingt-et-un Islands of Galveston, Turtle and East bays	16
Matagorda Island on Wynns Ranch across from Aransas National Wildlife Refuge in Mesquite, Ayres and San Antonio bays	2,315
Green Island and Three Island Tracts in Laguna Madre	182
Birds Island and North Deer Island in Chocolate and West Bay and the southwest part of Galveston Bay	40
Lydia Ann Island, portions of Harbor Island and small tracts in Copano, St. Charles, Aransas and Red Fish bays	304
Tract portions of the second chain of islands in San Antonio Bay	32
	2,884

Source: Texas Parks and Wildlife Department, 1974.

Table G-17 State Parks of Louisiana and Texas

Louisiana State Parks

Name	Hectares	Name	Hectares
Fort Macomb	7	Edward Douglas White State Monument	2
Fort Pike State Monument	51	Fairview Riverside	41
Longfellow-Evangeline	64	Nibletts Bluff Confederate Memorial	13
Bogue Falaya Wayside Park	5	Grand Isle	57
Fontainebleau	1,115	Cypremort Beach	75
Sam Houston	432	Rutherford Beach	N/A
St. Bernard	145		

Total Hectares 2,007*

* excluding Rutherford Beach

Texas State Parks

Name	Hectares	Name	Hectares
Sea Rim State Scenic Area	6,495	Sabine Pass Battleground State Park (undeveloped)	23
San Jacinto Battlefield State Historic Park	181	Galveston Island State Recreation Park (undeveloped)	777
Varner-Hogg Plantation State Historic Park	27	Bryan Beach State Park (undeveloped)	224
Mud Island State Recreation Park (undeveloped)	435	Port Lavaca Causeway State Recreation Park	1
Goose Island State Recreation Park	124	Copano Bay Causeway State Park	2
Mustang Island State Recreation Park (undeveloped)	1,445	Lipanitlan State Park	2
Brazos Island State Scenic Park	87	Port Isabel Lighthouse State Historic Site	1

Total Hectares 9,824

	Hectares	Total Hectares
Louisiana	5	2,005
Texas	6	9,823
	11	11,828

Source: Louisiana State Parks and Recreation Commission, 1974.
Texas Parks and Wildlife Dept., 1974.

small, encompassing a few acres up to a few hundred acres. Fontainbleau on Lake Pontchartrain's north shore is the largest Louisiana park listed at 1,115 hectares.

Local outdoor recreation facilities: In addition to Federal and State recreation areas, there are numerous city and county parks and recreation areas in the coastal zone. These facilities are generally located in and around the major population centers where the demand is greatest. In addition private and commercial recreation facilities exist in great numbers. The list could include marinas, tennis clubs, amusement parks and many others. Due to their large number, small size, and difficulty in obtaining comparable data for the entire Gulf area a complete mapping of these facilities was not attempted. This should not be construed as detracting from their importance in providing the bulk of day-to-day outdoor recreation opportunities for Gulf coast residents.

Recreation beaches: Wherever they are accessible for recreational use the sandy beaches along the Texas and Louisiana coasts are of major recreational importance. These beaches are also potentially vulnerable to offshore oil spills and to direct visual impact from any near-shore structures or lease generated traffic.

A detailed inventory of the Texas and Louisiana shoreline conditions is provided by the U.S. Army Corps of Engineers National Shore Line Study Regional Reports, 1971.

The three areas in coastal Louisiana which have experienced the most beach-oriented recreational development are Grand Isle, Vermilion Bay, and the southwest Louisiana coastline between Holly Beach and the mouth of the Mermentau River. Although there are many kilometers of beach shoreline, a large portion of it is very narrow, of poor recreational quality, and generally inaccessible.

Grand Isle is Louisiana's principal developed beach comprising about 11 km of Gulf beach ranging from 7 to 122 meters in width. Grand Isle State Park located on two tracts, one on each end of the island provides the public recreational facilities. The most popular activities are swimming and surf fishing.

Cypremort Beach and camping areas are the principal recreational developments along the eastern shore of Vermilion Bay.

In southwest Louisiana there are four beaches along the coast which have been developed by private interest. These are Ocean View, Constance, Peveto and Holly Beaches. Development here consists of summer homes and small commercial establishments. Rutherford Beach State Park, at the mouth of the Mermentau River provides recreational opportunities, both day-use and camping. Access to the southwest Louisiana beaches is from Louisiana Highway 82.

Other outdoor recreation areas of significant value in coastal Louisiana which are being considered as possible additions to the State park system are Isles Dernieres, Little Chenier (in Cameron Parish) and Chenier-au-Tigre (in Vermilion Parish).

The Cheniere region of southwestern Louisiana offers unique outdoor recreation opportunities. However, access by automobile is quite limited in some parts of the region. Little Chenier is an abandoned beach ridge about eight km long and up to 46 meters wide. This ridge and Cheniere-au-Tigre, dominated by moss-covered live oaks offer excellent opportunities for camping, picnicking, and sightseeing from a vantage point which provides a close look at the surrounding marshlands.

The Isles Dernieres is a 32 km long chain of barrier islands in Terrebone Parish. The topography of these islands consists of sandy beaches, low grassy dunes, and sand flats, salt marsh and mangrove swamp. This environment provides a habitat for a wide variety of birds, most importantly herons and egrets. There is no development on the islands other than a large cabin and docking facility in the Whiskey Island group. There are no roads, trails, or utility services. Oil fields surround the islands but there is no industry activity on the islands. Access is possible only by boat or airplane.

The most popular recreational activity on the Isles Dernieres is sport fishing from the beach or offshore in the surrounding waters. Camping, picnicking, and sightseeing are also done but most often in conjunction with sport fishing. Use of the island for other recreation is limited because of limited access and frequent flooding by storm tide.

Table G-18 gives selected data for Louisiana and Texas.

The Texas and Louisiana shore is approximately 1,200 miles (1,931 km), 700 miles (1,126 km) of which are sand beaches and 500 miles (805 km) non-beach shore, usually marsh or mangrove. Bay and estuarine shoreline is much greater, totaling

Table G-18 Gulf of Mexico - Selected Shoreline Information

Location	Physical Characteristics: Shore Length	Beach Length	Non-Beach Shore	Shore Ownership: Federal	Non-Federal Public	Private	Shore Use: Public Recreation	Private Recreation	Non-Recreational Deve.	Undeveloped
	(Miles of Shore)									
A. Gulf Shoreline										
Louisiana	810	365	445	160	181.9	468	7.5	2.1	7.2	793.2
Texas	373	361	12	96	12	265	270	41	0	62
Sub-Total	1,183	726	457	256	193.9	733	277.5	43.1	7.2	855.2
B. Bay and Estuary Shore										
Louisiana	1,133	470	663	85.4	150	897.6	10.3	26.1	39.1	1,057.5
Texas	2,125	16	2,109	292	43	1,790	116	119	107	1,783
Sub-Total	3,258	486	2,772	377.4	193	2,687.6	126.3	145.1	146.1	2,840.5
Total Shoreline	4,441	1,212	3,229	633.4	386.9	2,760.6	303.8	188.2	153.3	3,695.7

Extracted From: Department of Army: Corps of Engineers, 1971b

Data in miles

about 4,400 miles (7,080 km), with a much lower ratio of beach to non-beach shoreline. Public ownership of the total Texas-Louisiana shoreline is about twenty-three percent and approximately eleven percent is used for recreation, public and private.

Sand beaches are identified on Visual No. 1 (Volume 3).

Louisiana has very limited beach area suitable for recreation. The three areas in coastal Louisiana which have experienced the most beach-oriented recreational development are Grand Isle, Vermilion Bay, and the southwest Louisiana coastline between Holly Beach and the mouth of the Mermentau River. Although there are many kilometers of beach shoreline, a large portion of it is very narrow, of poor recreational quality and generally inaccessible.

The Texas coast has 373 miles (600 km) of shoreline facing the Gulf of which 361 miles (581 km) is beach shore. The much more extensive Bay and estuarine shore has very little beach area. An estimated 270 miles (434 km) of Gulf beach are used for public recreation. The mainland shore is paralleled by barrier islands except at Sabine Pass, the Brazos River delta and the entrances to bays and lagoons. These barrier islands range in width from a few hundred meters to five km and are separated from the mainland by shallow coastal lagoons, five to eight km wide. This double shoreline combined with the sub-tropical climate and gentle terrain of the region provide conditions favorable for year-round outdoor recreation. As previously mentioned, the Padre Island National Seashore faces the Gulf with about 129 km of excellent beach from Corpus Christi southward.

The Texas "open beach law" passed by the Texas Legislature in 1959 provides for public access and use of the beaches having open Gulf exposure from the mean low tide to the vegetation line. Not all beaches are physically for recreation use and there remain some legal questions relating to full public utilization of Texas beaches.

Miscellaneous recreation resources: Several additional significant recreational resources are found along the Gulf coast. Louisiana contains ornamental gardens, and scenic roads and rivers have been designated in Louisiana and Texas. Louisiana has just completed a statewide trails development plan indicating a widespread interest in hiking and biking facilities.

There are two major ornamental gardens in Louisiana; north of Vermilion Bay are found the Avery Island Jungle Gardens and Rip Van Winkle Gardens.

Historical Resources

The National Register of Historic Places was the major source consulted for historical sites, (Federal Register, 1976). The State Historical Preservation Officers for Texas and Louisiana were contacted to determine if any historical or archaeological sites potentially eligible for the National Register are located in the Gulf OCS area. None are known at the present time within the area to be affected by this sale.

The National Register of historic sites and the number of recorded archaeological sites in each Gulf coastal county are shown on Visual No. 1, Volume 3.

Archaeological Resources

Evidence of human habitation dating back thousands of years can be found throughout Texas and Louisiana. Archaeological sites are reported in all counties and parishes bordering the Texas and Louisiana coastlines. The total number of sites known and recorded in each county is shown on Visual No. 1.

Because of the sensitive nature of the location of archaeological sites, only those major sites which are of general public knowledge or are afforded protection are individually shown on the visuals. There are certain sites on the National Register of Historic Places.

For the sixteen Texas counties adjacent to the Gulf, 1,359 archaeological sites had been recorded by September, 1974. A total of forty-three of these sites had been excavated and an estimated five percent of the total area had been systematically surveyed for archaeological sites. Individual coverage ranged from no systematic survey in Aransas County to approximately 15 percent coverage in Cameron, Jackson and Kleberg Counties (Texas Archaeological Res. Lab., 1974). There are 594 known sites in Louisiana parishes bordering the Gulf.

Additional discussion of archaeological resources can be found in the Department of the Interior's Final Environmental Statements for OCS Sale No. 38, FES 75-37 (central Gulf), Vol. I, pp. 237-241; and OCS Sale No. 37, FES 74-63 (western Gulf), Vol. I, pp. 355-363.

Submerged archaeological sites: There is increasing interest in submerged sites of archaeological value offshore on the continental shelf or in estuaries and embayments. Because man has inhabited the Gulf coast region for thousands of years, there was human occupation in the area at a time when sea level was much lower than it has been within historic times.

Shipwrecks: The waters of the northern Gulf of Mexico contain numerous shipwrecks dating back to the early sixteenth century. Considerable work has been done in the archives of Mexico, Spain and many other countries to identify and locate early casualties in the Gulf of Mexico. More modern losses may be identified by the U.S. Navy, Coast Guard, and insurance company records or other contemporary sources.

A Department of Interior study is nearing completion by Dr. Sherwood Gagliano to determine the zones of highest probability within the northern Gulf of Mexico for the occurrence of historically significant shipwrecks, as well as the potential for submerged human dwelling sites.

Texas is an area of particularly active shipwreck research. Briggs (1971) lists 83 known wrecks along the Texas coast dating from 1552 to 1897. Mr. Carl Clausen has conducted extensive underwater surveys in Matagorda Bay and along Padre Island for the Texas State Antiquities Commission. A number of the anomalies discovered are believed to be early shipwrecks, and one site, designated 41KN10, was excavated in 1972 yielding artifacts of an early Spanish galleon.

These surveys, which are being gradually extended along the coast, by Mr. J. Barton Arnold for the Texas Antiquities Commission, are conducted close to shore and well within state waters.

Transportation

General

The ports and harbors along the Gulf coast from New Orleans to Corpus Christi are shown in Table G-19 which show the magnitude of waterborne traffic over the entire area where the oil products originating from the porposed tracts may be transported by barges or tankers.

Of the 417 million tons (379 million metric tons) of freight that passed through the 12 ports and harbors in 1973 as shown in Table G-19, 200 million tons (182 million metric tons) or almost 48 percent was crude oil and petroleum products. Also, of these same 417 million tons (379 million metric tons) of freight, 141 million tons (128 million metric tons), or approximately 34 percent moved in foreign trade (imports plus exports) and of this foreign trade 32 million tons (29 million metric tons), or 33 percent was crude oil and petroleum products.

As is shown on the Figure G-6 the Gulf Coastal Zone is well served by all forms of transportation. An extensive network of highways and rail lines connect all major ports with inland areas. Transportation throughout the coastal counties is primarily via roads and highways. The following table gives total roads and highways mileage by state and total number of motor vehicle registrations (autos, trucks and buses) by state.

[Registration figures rounded to nearest thousand]

	Road and highway mileage, 1971	Motor vehicle registrations, 1972
Louisiana	53,340	1,942,000
Texas	248,340	7,316,000

From U.S. Federal Highway Administration, Highway Statistics, 1971.

Because of their geographic location, the coastal counties are also served extensively by waterborne transportation systems. A number of important U.S. ports are within the Texas and Louisiana area.

The Port of New Orleans is the second largest port in the nation, Houston is the third largest and Corpus Christi is the ninth largest U.S. port. The deep water ports along the Texas coastline are Beaumont, Brownsville, Corpus Christi, Freeport, Galveston, Houston, Orange, Port Arthur, Port Isabel, Port Lavaca, Point Comfort, Texas City and Sabine Pass Harbor.

Louisiana

The major arteries of Louisiana are the rivers and waterways, and the Mississippi River is the principal route. Two major interstate highways cross the northern and southern parts of the State and are paralleled by the intracoastal waterway, air, and rail transportation. The following description of the transportation systems in the Louisiana coastal zone is quoted from the Louisiana Advisory Commission on Coastal and Marine Resources, (1973a).

TABLE G-19

FREIGHT TRAFFIC AT MAJOR PORTS
OF THE GULF COAST, NEW ORLEANS - CORPUS CHRISTI

Freight Traffic (Short Tons X 1000)
- 1973 -

Port	Total Freight Traffic	(SIC 13) Crude Petroleum	(SIC 29) Petroleum Products	Total Foreign Trade	Total Petroleum in Foreign Trade	Petroleum Products as a % of Foreign Trade	Petroleum Products in Foreign Trade as a % of Total Port Activity
New Orleans	136,104	23,236	20,925	46,472	3,490	[illegible]	[illegible]
Baton Rouge	53,568	5,115	15,870	17,442	2,107	12	04
Lake Charles	16,505	7,766	3,763	2,578	1,251	45	08
Orange	1,280	72	61	70	00	00	00
Beaumont	34,491	11,342	13,865	9,618	4,908	51	14
Port Arthur	24,931	7,153	14,905	6,475	4,347	67	18
Houston	88,518	11,390	31,753	33,429	7,371	22	08
Texas City	19,959	4,844	8,728	3,279	2,575	79	13
Galveston	6,887	32	319	5,250	231	04	03
Freeport	7,348	2,410	617	3,420	1,933	57	26
Corpus Christi & Harbor Island	27,171	7,225	8,569	13,067	3,765	29	14
TOTALS	416,782	80,585	119,375	141,110	31,978	23%	8%

TOTAL PETROLEUM PRODUCTS AS A % OF TOTAL PORT ACTIVITY 0% 48%

Source: U.S. Dept. of the Army, Corps of Engineers. Waterborne Commerce of the United States. 1973.

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

0 20 40 60 80 100
SCALE IN MILES

FIGURE
G-6
MAJOR LAND AND SEA TRANSPORTATION ROUTES FOR COASTAL COUNTIES. GULF OF MEXICO - COASTAL REGION

Highway transportation:

In the coastal zone, Louisiana maintains more than 9,700 km of non-rural roadway. The principal traffic routes through the coastal zone are shown in Figure G-7 The coastal zone also has more than 11,300 km of local rural roads.

The area along the coast generally has suffered from a lack of feeder roads. This is traceable to the fact that soil conditions in the area make road construction costly.

Railroad transportation:

In 1970, there were more then 6,900 km of main line track in Louisiana. Figure G-8, presents an outline of this system.

The primary east-west line in the coastal parishes is Southern Pacific, which runs from New Orleans westward to Morgan City, Lafayette, Lake Charles and ultimately to California. The main line roughly parallels the coast but is located well inland.

The Missouri Pacific traverses an east-west route roughly parallel to U.S. 190.

Texas Pacific serves the western bank of the Mississippi River as far south as Venice, Illinois Central also provides a north-south line from New Orleans to Illinois. Southern Railway System and the Gulf, Mobile and Ohio Railroad Company provide north-south service around the eastern end of Lake Pontchartrain. The Louisville and Nashville Railroad provides service from New Orleans eastward along the Mississippi Gulf Coast.

Air transportation:

The coastal zone of Louisiana is served by four commercial airports. These include:

Baton Rouge—Ryan Field
Lafayette—Lafayette Municipal Airport
Lake Charles—Lake Charles Municipal Airport
New Orleans—Moisant (New Orleans International) Airport

Numerous other cities and towns, have unlighted, hard surface, landing strips or airports. However, most of the air facilities are located at least 16 km inland. A number of heliports and seaplane facilities have been constructed on the coast. They are generally concentrated around Morgan City, Grand Isle and Venice and serve the petroleum industry as refueling stops for aircraft transporting workmen to offshore oil rigs from other airports in the more populated areas.

Pipeline transportation:

There are 31 gas transmission companies operating in Louisiana and 34 petroleum and petroleum product pipeline companies. Most pipelines are automated.

That network is likely to grow for natural gas activity and stabilize for petroleum activity based on production predictions in the following two tables prepared by Associated Louisiana Planning Consultants, Incorporated for the Comprehensive State Plan (Table G-20 and G-21).

Development of a deep-draft port in the Gulf of Mexico in the vicinity of the Mississippi River may anticipate construction of connector pipelines to the offshore terminal as the main method of moving bulk liquids. Port facilities and water transportation:

At least 8 km of navigable streams and 1,800 km of intercoastal waterways are located in the state (Louisiana Planning Corporation, 1972. Vol. 1, p. 322). These waterways include the Mississippi River and the Gulf Intracoastal Waterway which are major waterways for the nation's waterborne commerce. Other notable waterways include the Calcasieu, Atchafalaya, Ouachita, Mermentau, Vermilion, and Pearl River, Barataria Bay, Bayou La Fourche, the Houma Navigation Canal, and the Bayous Petit Anse, Tige, Carlin and Teche.

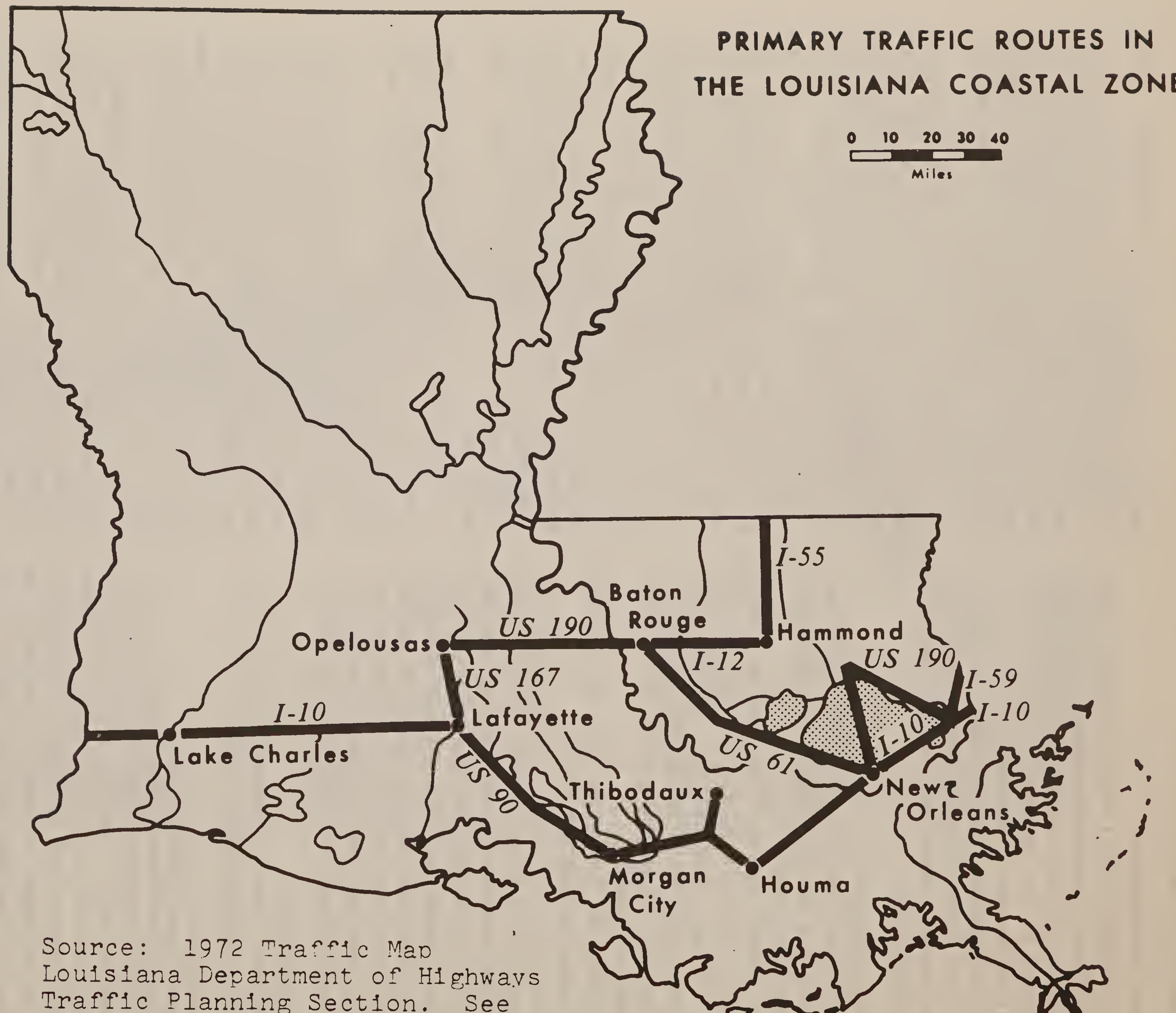
Several major ports have developed in southern Louisiana. Three of these, New Orleans, Baton Rouge, and Lake Charles, rank among the major ports of the United States.

New Orleans is the largest port on the Gulf of Mexico. Upstream from New Orleans on the Mississippi River is the Port of Baton Rouge, the seventh ranked port in the nation in terms of tonnage. Bulk cargoes, petroleum and petroleum products, grains, and ores flow through these ports. Lake Charles, the state's third deepwater port, ranks twentieth in the nation. Lake Charles has bulk cargo operations consisting primarily of petroleum and its derivative products, as well as moderate amounts of general cargo. Total tonnage handled by these three ports from 1955-1973 is shown in Table G-22.

The following description of Louisiana ports was abstracted from U.S. Department of the Army, 1973.

New Orleans:

The Mississippi River has a clear and unobstructed channel maintained to a depth of 12 m from New Orleans to the mouth of the river. The frontage for deepwater vessels within the port



Source: 1972 Traffic Map
Louisiana Department of Highways
Traffic Planning Section. See
Table 2.10 for typical daily traffic
load.

Fig. G-7

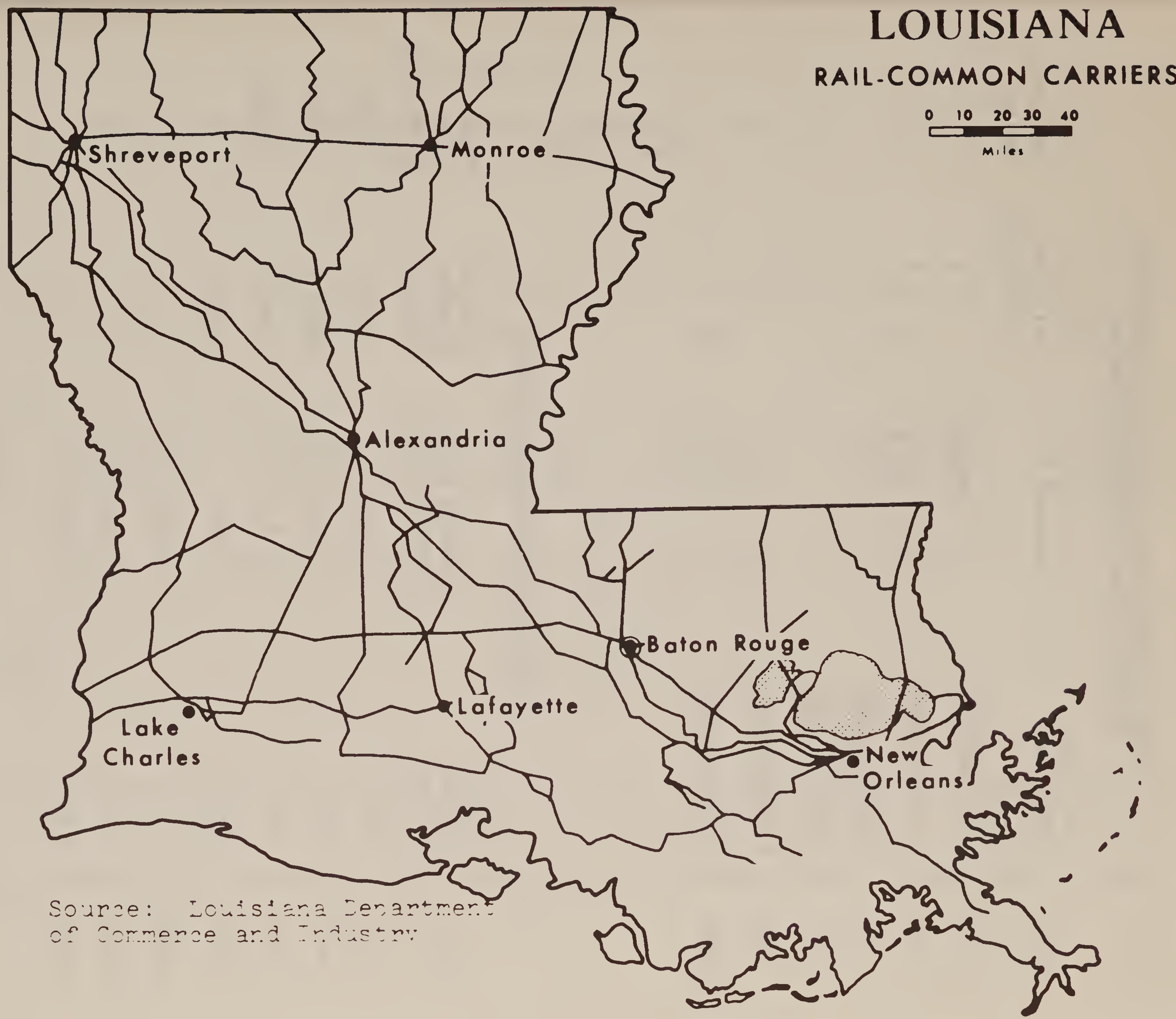


Fig. G-8 Source: Louisiana Department of Commerce and Industry

Table G-20

Sales by Louisiana Producers of Natural Gas to Natural Gas Pipeline Companies

Year	Million Cubic Feet	Revenue	Cents per Million Cubic Feet	% of National Sales
1953	965,000,000	$ 88,000,000	9.1	20.5
1961	2,494,738,257	498,993,710	20.0	29.9
1970	4,990,000,000			
1975	5,900,000,000			
1980	6,500,000,000			
1985	7,150,000,000			

Table G-21

Petroleum Pipeline Activity

Year	Miles of Pipeline In Place	Pipeline Fill (1,000 Barrels)	Miles of Produce Line	Miles of Crude Truck Line
1953	5,659	2,474	616	2,872
1961	6,598	3,791	1,704	2,465
1970	6,765	5,770	2,045	Stable
1975	7,000	5,920	2,450	
1980	7,210	6,230		
1985	7,430	6,570		
2000	7,650	7,460		

Source: Louisiana Office of State Planning, 1972. Initial elements toward a comprehensive state plan.

TABLE G-22

TOTAL TONNAGE HANDLED BY MAJOR LOUISIANA PORTS, 1955-1973
(In Tons of 2,000 Pounds)

Port	1955	1960	1965	1967	1969	1973
Baton Rouge	16,489,779	26,585,815	31,658,797	37,273,286	40,845,124	53,568,530
Lake Charles	15,396,366	17,433,441	14,469,783	16,697,672	16,154, 84	16,505,262
New Orleans	47,082,734	56,671,652	88,876,872	111,491,062	113,426,557	136,104,315
U. S. Total	1,016,136,785	1,099,850,431	1,272,896,243	1,336,606,078	1,448,711,541	
Louisiana as a Percentage of U. S.	7.67	9.15	10.60	12.38	11.77	

Source: U. S. Department of the Army, Corps of Engineers, Waterborne Commerce of the United States, 1974.

limits includes approximately 92 km along the riverbanks, 18 km on the Inner Harbor Navigation (Industrial) Canal, and approximately 126 km on the Mississippi River—Gulf Outlet. The Inner Harbor Navigation (Industrial) Canal in the City of New Orleans connects the Mississippi River with Lake Pontchartrain, and the Gulf Intracoastal Waterway east of New Orleans.

There are about 295 piers, wharves, and docks in the Port of New Orleans area. Twenty-three waterfront facilities are equipped to receive and/or ship petroleum products; several of these facilities provide bunkering services for vessels. Four companies maintain facilities for public storage, drumming, blending, packaging and distributing of various types of bulk liquids. They operate six wharves along the right bank of the Mississippi River with waterside connections and pipelines extending to storage tanks in the rear with total storage capacity of about 2,839,000 barrels.

The port area is served by six railway companies. Interstate, Federal, and state highways connect New Orleans with other points in Louisiana and the United States. See Table G-22 for commodities and tonnage shipped on the Mississippi River system.

BATON ROUGE:

The Port of Baton Rouge, Louisiana, is on both banks of the Mississippi River 418 km from deep water in the Gulf. It is at the head of the deep-draft channel of the Mississippi River. The port is also served by a direct connection with the Gulf Intracoastal Waterway via the Port Allen Lock and the Gulf Intracoastal WaterwayAlternate Route which extends from Morgan City to Port Allen. The existing project dimensions above New Orleans are 12 meters deep (mean low water) by 152 meters wide.

Thirteen waterfront facilities are equipped to receive and/or ship crude oil and petroleum products. There are about 890 storage tanks capable of storing approximately 23,269,999 barrels of crude oil and petroleum products.

The port area of Baton Rouge is served by the Illinois Central Railroad; Louisiana & Arkansas Railway (Kansas City Southern Lines). Interstate, Federal and state highways connect Baton Rouge with other points in Louisiana and the United States.

PORT OF LAKE CHARLES:

The port of Lake Charles is in the southeastern part of the State of Louisiana and embraces an area of 526 square kilometers. The Calcasieu River flows in a southerly direction from the port for a distance of 56 km to enter the Gulf of Mexico.

The existing project provides for a 13 meter by 244 meter approach channel with a 12 meter by 122 meter channel to the wharves of the port of Lake Charles.

Storage facilities are maintained for about 13,200,000 barrels of crude oil and refined petroleum products. The port area is served by the Kansas City Southern Railway, the Missouri-Pacific Railroad, and the Southern Pacific Company. Interstate Highway 10, U.S. Highway 90 and state highways connect Lake Charles with other parts of Louisiana and the United States.

The Gulf Intracoastal Waterway, which extends from Apalachee Bay, Florida, to Brownsville, Texas, crosses the Calcasieu River about 18 km below the city of Lake Charles. The Waterway section to the east provides a connection with the Mississippi River System at New Orleans, and westward from the Calcasieu River to the Sabine-Neches Waterway.

INTRACOASTAL SHIPPING:

Aside from deep-draft ocean shipping, Louisiana is a key focal point for inland waterway traffic. Inland barge traffic not only links the deepwater ports to the interior of the nation but also provides important support for the industrial structure of coastal Louisiana.

In terms of cargo destined for ocean shipping, the principal commodities carried on the inland waterways are petroleum and petroleum products, grains and grain products, aluminum ores, concentrates and scrap, soybeans, and liquid and dry sulfur. The domestic cargo tonnage moved along Louisiana waterways consists primarily of petroleum and petroleum products, grain and grain products, soybeans, sand, gravel, crushed rock, iron and steel products, sulfur, and other chemicals.

Barge traffic is especially important to the petroleum and chemical industries in Louisiana since it not only supplements pipelines to a considerable extent but also provides low-cost movement of refined petroleum and chemicals to the interior of the nation and to the deep-water ports

for trans-shipment. The existence of barge service concentration of petro-chemical facilities adjacent to water sites in Louisiana.

The importance of the petroleum related industries can be seen in Table G-23. Of the total tonnage handled at the major Gulf Coast ports from New Orleans through Brownsville, approximately 19 percent consisted of "Crude Petroleum" (SIC 13), and 29 percent consisted of "Petroleum and Related Industries" (SIC 29).

Texas

The principal reference for the following text and figures was Transportation in the Texas Coastal Zone (Texas A & M University, 1973). Much of the following was taken verbatim from that reference.

Highway transportation

Highways form the backbone of the transportation system serving the land areas within the Coastal Zone. Most of the 19,308 km of highways crisscrossing the Coastal Zone are presently operating at less than half of their capacity in rural areas; however, traffic volumes increase sharply as these highways approach urban areas.

Rail transportation

The Texas Coastal Zone is served by an extensive network of railroads that connect the region to the rest of the State and the nation. The 4,809 km of main-line tracks represent more than 21 percent of all railroad kilometers in Texas.

A total of 55 million tons (50 million metric tons) of rail freight is estimated to originate, terminate, or pass through the Coastal Zone each year. This represents about 28 percent of all rail freight tonnage reported by Texas railroads. The bulk of this rail traffic is estimated to be in corridors connecting the Coastal Zone to other regions.

A comparison of the estimated traffic volumes in major rail corridors serving the Coastal Zone is presented in Figure G-9 The heaviest rail traffic occurs in the corridor connecting Houston to Dallas-Fort Worth area and points north. An estimated 21 million tons (19 million metric tons) per year are carried in this corridor. None of the rail corridors serving the Coastal Zone are presently operating at more than 20 percent of the basic capacity provided by the rail lines.

Air transportation

Eight airports in the Coastal Zone are presently served by scheduled air passenger service. Almost three million passengers boarded planes at these airports in 1970.

Pipeline transportation

The total capacity of pipelines entering or leaving the coastal zone is sufficient to transport more than 150 million tons of crude oil and petroleum products each year. This capacity is distributed among the major corridors as shown in Figure G-10. In addition, numerous gas pipelines traverse the area.

Port facilities and water transportation

Texas ports handle three basic types of waterborne traffic: foreign, domestic and internal. Of the total tonnage handled 64 percent was shipped out, and 36 percent was received.

Of the ocean traffic, about two-thirds is domestic commerce and the remainder is in foreign trade. The bulk of this outbound tonnage is liquid petroleum products.

The waterway traffic is primarily on the Gulf Intracoastal Waterway, which extends from Brownsville, Texas, to Apalachee Bay, Florida. Its 1791 km of canals, of which 681 km are in Texas, connects all ports on the Gulf of Mexico to more than 9654 km of inland waterway centering on the Mississippi River. Recent industrial expansion in the Texas coastal zone has been closely related to the waterway, as more than four out of every five additional tons of waterborne traffic developed in the past 15 years have been on the canal.

No locks are required through Texas, as all portions of the canal are at sea level. Almost 70 million tons (64 million metric tons) of goods were loaded onto or unloaded off of barges at Texas ports each year from 1967 to 1970.

About 36 million tons (33 million metric tons) of waterway traffic crossed the Texas-Louisiana border in 1970, about 60 percent of which was coming into Texas.

Since approximately half of the nation's petrochemical industry and one-fourth of its refining capacity is located in the Texas coastal zone, products from these industries comprise the bulk of total waterborne tonnage for both ocean-going and barge traffic. The importance of the petroleum related industries can be seen in Table G-24. Of the total tonnage handled at Texas ports, ap-

TABLE G-23

FREIGHT TRAFFIC AT MAJOR PORTS
OF THE GULF COAST, MOBILE-BROWNSVILLE

Freight Traffic (Short Tons X 1000)
- 1973 -

PORT	TOTAL	CRUDE PETROLEUM (SIC 13)	PETROLEUM PRODUCTS (SIC 29)
New Orleans	136,104	23,236	20,925
Baton Rouge	53,568	5,115	15,870
Lake Charles	16,505	7,766	3,763
Orange	1,280	72	61
Beaumont	34,491	11,342	13,865
Port Arthur	24,931	7,153	14,905
Houston	88,518	11,390	31,753
Texas City	19,959	4,844	8,728
Galveston	4,550	32	319
Freeport	7,348	2,410	617
Corpus Christi and Harbor Island	27,171	7,225	8,569
Brownsville - Port Isabel	6,377	3,791	1,046
TOTALS	420,802	84,376	120,421

Compiled from figures in U. S. Department of the Army, 1973.

RAIL LINES IN THE TEXAS COASTAL ZONE

An extensive network of 2989 miles of main-line railroads serves the Texas Coastal Zone. Excellent rail connections link the Coastal Zone to the rest of the State and the nation.

FIG. G-9

Figure G-10 Crude Oil Pipeline Capacities

Source: *National Petroleum Council*

Table G-24 FREIGHT TRAFFIC AT MAJOR PORTS OF THE TEXAS GULF COAST

FREIGHT TRAFFIC (SHORT TONS X 1000)
(1972)

PORT	TOTAL	CRUDE PETROLEUM (SIC 13)	PETROLEUM PRODUCTS (SIC 29)
Orange	1,486	102	47
Beaumont	32,391	10,646	13,715
Port Arthur	21,708	3,436	16,054
Houston	71,431	6,327	28,430
Texas City	20,355	5,252	8,732
Galveston	4,274	15	78
Freeport	5,977	945	985
Corpus Christi and Harbor Island	25,496	6,600	9,485
Brownsville - Port Isabel	4,354	2,381	475
TOTAL	187,472	35,704	78,001

Compiled from figures in U. S. Department of the Army, 1973.

proximately 19 percent consisted of "Crude Petroleum" (SIC 13), and 42 percent consisted of "Petroleum and Related Industries"—(SIC 29).

Including the petrochemical industry, it has been estimated that approximately 85 percent of all tonnage handled at Texas ports consists of crude oil or petroleum products (University of Texas, 1973).

The following description of Texas ports was abstracted from U.S. Department of the Army (1973).

Port Arthur

The port of Port Arthur has an authorized depth of 13 meters and a width of 244 meters through the outer bar channel and a depth of 12 meters and a width of between 60 and 203 meters. The principal waterborne commodities handled at the port are crude petroleum, petroleum products, and chemicals.

Storage facilities include about 25,932,000 barrels of storage for crude oil and refined petroleum products. Railroad facilities include about three km of marginal trackage. Three federal highways and state highways connect Port Arthur with other parts of Texas and the United States.

Orange

The channel to the port of Orange has an authorized depth of nine meters and a width of 46 to 60 meters. The principal waterborne commodities handled at the port are shell, crude petroleum, and chemicals. There are 35 piers, wharves and docks.

Storage facilities include transit sheds and about 447,000 barrels of storage for crude oil and refined petroleum products. The Orange area is served by Interstate Highway 10, U.S. Highway 90, two railroad companies and other state highways.

Beaumont

This port has an authorized channel depth varying from nine to 12 meters in width varying from 60 to 120 meters. The principal waterborne commodities handled at the port are crude petroleum, petroleum products, chemicals, liquid sulphur and wheat.

Storage facilities include elevators for grain, dry storage space, and about a 39,500,000 barrel capacity of storage tanks for crude oil and refined petroleum products. The port area of Beaumont is served by several railway companies. Interstate Highway 10 and several U.S. and state highways connect Beaumont with other points of Texas and the United States.

Galveston

The Galveston Channel has an authorized depth of 12 meters and width of 366 meters.

Storage facilities include grain elevators, dry storage, cooler and freezer space, storage tanks for liquid sulphur, and storage facilities for an unlimited supply of dry sulphur.

Waterfront terminals at Galveston are served by a railroad which connects with several other railroads serving Galveston and the port area. Interstate 45 and State Highway 87 connect Galveston with the Texas mainland and the United States.

Houston

The Houston Ship Channel affords access for ocean-going vessels from the Gulf of Mexico to Houston. It also provides access to barge traffic from the Gulf Intracoastal Waterway. Some of the principal commodities handled at the port are petroleum and petroleum products, sand and shell, fertilizer and fertilizer materials, steel mill products, grain, sulphur, clay and earths, and chemicals. There are 218 piers, wharves and docks in the vicinity of the port of Houston.

Storage facilities include five grain elevators, 21 warehouses, cooler and freezer space, and about 11,928,000 barrels of storage tanks for crude oil and refined petroleum products. The port area of Houston is served by many railroads. Two interstate highways and several U.S. and state highways connect Houston with other points in Texas and other points in the United States.

Texas City

The dimensions of the authorized channel are 12 meters deep, 122 meters wide, and about six km long, with 12 meter depths also authorized for the turning basins and industrial canal.

The harbor area includes about 11,175,000 barrels of storage for crude oil and refined petroleum products. The Texas City Terminal Railway has marginal tracks in the vicinity of the harbor area and connects with other railroads. State Highway 197 connects the Texas City area with other state and Federal highways.

Freeport

The port of Freeport is a major port for shipping chemicals and petroleum products.

Storage facilities include about 20,066 square meters of transit sheds, private storage facilities for about 700,000 barrels of crude oil, and for about 1,350,000 barrels of petroleum products. Railroad facilities include about 914 meters of marginal trackage. Federal and state highways connect Freeport with other parts of Texas and the United States.

Port of Port O'Connor

The waterfront facilities in the area, excluding shallow-draft channels and turning basins, consist of a turning basin with approximately 914 meters of usable berthing space and about 2,892 square meters of transit sheds. There are no storage facilities for crude petroleum. Railroad facilities include trackage connecting to the Missouri-Pacific Railroad. State Highway 35 is the primary highway.

Port of Corpus Christi

Storage facilities include about a 25,430,000 barrel capacity of storage tanks for crude oil and refined petroleum products.

All of the publicly-owned, as well as some of the privately-owned waterfront terminals at the port of Corpus Christi are served by terminal trackage. Several U.S. and state highways connect with other parts of Texas and the United States.

Port of Brownsville

Port Brownsville is the southernmost port in Texas and the southern terminus of the intracoastal waterway system.

The main harbor consists of about 5 km of improved waterfrontage, cargo docks, covered and open storage, and grain storage. Railroad service is provided by three companies and the harbor is also served by the Gulf Intracoastal Waterway and state and federal highways.

Commercial Fishery Resources

By far the most productive region of the Gulf of Mexico, where most of the fishery concentrates, is around the Mississippi Delta, with approximately 1/3 to 2/5 of the total production taken on the eastern side (Juhl, 1974). The total U.S. landings of the 1974 were 4.9 billion pounds (U.S. Dept. Commerce, 1975) valued at $898.5 million at the ex-vessel level. Landings in the Gulf waters of the U.S. accounted for 36.1% or 1.77 billion pounds and 26.8% or 240.8 million of the U.S. catch.

The Gulf fishery is dominated by the shell fisheries, and especially by shrimp, crabs and oysters (with smaller amounts of clam and scallops), usually worth three or four times more than the much greater volume of fin fish. The main shrimp fishery in the Gulf area includes brown, white and pink shrimp. These are taken almost exclusively with trawls, in depths ranging from one to forty fathoms. Other shrimp taken commercially are the sea bobs and royal reds.

Based on 1973 statistics for grid zones 10-21, brown shrimp (*Penaeus aztecus*) comprised 59% of the catch, white shrimp (*P. setifeus*) 37%, and pink shrimp (*P. duorarum*) one percent. Catches of sea bob (Xiphopeneus kroyeri) and the deepwater royal reds (*Hymenpenaeus robustus*) were also reported, and accounted for three percent of the catch. The areas of greatest harvest were grid zones 19, 13, and 14 (Table G-25). Visual No. 5 for the Western Gulf and Central Gulf depict grid zones and location of major coastal zone and offshore fishery areas. The percent of brown and white shrimp catch for 1970-1974; for offshore from the Mississippi River to Texas are shown in Tables G-26 and G-27.

In 1974 the Gulf states shrimp fishery accounted for 50 percent of the total volume and 77 percent of the total value. In addition, Texas was again the leading state in value with $67.7 million, and the second state in production with 78.7 million pounds. Louisiana was second in value with $32.1 million, and third in production with 59.5 million pounds.

Compared with 1973, landings along the Gulf coast of 185.7 million pounds increased two percent, but the value ($137.4 million) declined 21 percent. For oyster production, Louisiana led with 9.0 million pounds, followed by the west coast of Florida with 2.4 million and Texas with

Table G-25 SHRIMP CATCH BY GRID ZONE FOR 1973 1/

SPECIES	GRID 13	14	19
Brown	7,957,511	7,269,074	7,329,790
White	3,293,747	2,431,257	6,384,465
Pink	12,181	-0-	-0-
Other	276,820	277,741	2,941
TOTAL	11,540,259	9,978,072	13,717,196
Trips	65,000	65,660	35,707

1/ Includes inland waters and weight in pounds (heads off).

Source: Gulf Coast Shrimp Data Summary
U.S. Department of Commerce, 1973

Table G-26 PERCENT BROWN SHRIMP LANDINGS (LBS.) BY WATER DEPTH, 1970-1974, OFFSHORE - MISSISSIPPI RIVER TO TEXAS

Depth (ft.)	1970 %	1971 %	1972 %	1973 %	1974 %
0-60	24.63	33.87	23.01	37.17	20.75
60-120	28.24	35.74	22.66	8.73	23.74
120-180	34.67	18.96	35.39	16.3	29.83
180+	12.45	11.42	18.95	37.34	25.69

Source: Gulf Coast Shrimp Data, Summary
U. S. Department of Commerce, 1974

Table G-27 PERCENT WHITE SHRIMP LANDINGS (LBS.) BY WATER DEPTH, 1970-1974, OFFSHORE - MISSISSIPPI RIVER TO TEXAS

Depth (ft.)	1970 %	1971 %	1972 %	1973 %	1974 %
0-60	85.04	89.53	90.61	94.85	91.55
60-120	14.03	9.55	8.80	4.78	6.65
120-180	0.87	0.83	0.44	0.22	1.67
180+	0.07	0.09	0.15	0.17	0.12

Source: Gulf Coast Shrimp Data, Summary
U. S. Department of Commerce, 1974

1.3 million pounds. The oyster harvest declined generally in the Gulf area, principally because of floods in 1972 and 1973.

Louisiana also led in crab production with 20.6 million pounds. Production for the Gulf states was 39.6 million pounds which represented six percent less than in 1973.

Finfish volume for the Gulf states is dominated by menhaden. It is number one in both volume and value for the Gulf States. Landings in 1974 were 1,295.9 million pounds—223.0 million (21 percent) more than in 1973 or 65.5 percent of the U.S. menhaden catch. Louisiana led all states with 1,079.3 million pounds—up 184.4 million compared with 1973.

Hopkins and Petrocelli (1974) stated that nearly all of the Gulf coast catch, including practically all of the menhaden, is made within the waters of the United States, or in international waters within a few miles of the U.S. coast. Of the important commercial fishes, only groupers and red snappers are caught mainly beyond the 12-mile limit, and they make up only one percent of the volume and two percent of the value of the total Gulf coast catch. However, of the shrimp landed at Gulf ports some 20 percent are caught in international waters off foreign shores, mainly Mexican.

As Gunter (1967) has pointed out, 97.5 percent of the total commercial fisheries catch of the Gulf states is made of estuarine species, that is, fishes or shell fishes that spend all or part of their lives in estuaries. A few species, such as the commercial oyster, live their lives in estuarine waters.

On the Gulf coast as a whole, the usual ranking of the most important commercial fishes is as shown below:

By volume	*By value*
Menhaden	Menhaden
Mullet	Mullet
Croaker	Croaker
Red Snapper	Spotted Seatrout
Groupers	Croaker
Spanish Mackerel	Groupers
Spotted Seatrout	Pompano
Red Drum	Spanish Mackerel
Flounders	Red Drum
Black Drum	Flounders
King Whiting	King Mackerel
White Seatrout	Black Drum
Sheepshead	White Seatrout
	Sheepshead

Table G-28 is a statistical summary of landings, fisherman, plants and ranking in the United States for the Gulf States.

A visual representation for the coastal zone and offshore fisheries is in Vol. 3, Visual No. 5; western and central Gulf of Mexico. In addition, two years (1972-1973) averages for brown, white and pink shrimp are given and location of royal red shrimp grounds, major inshore shrimp areas, major crabbing areas and oyster grounds are illustrated. Finfish are identified as to major species, both sport and commercial, and grid zones in which they are commonly caught. Shell dredging areas are also identified.

Table G-28

LANDINGS BY STATES FOR GULF OF MEXICO 1973 - 1974 1/

	1973				1974			
	Thousand Pounds	%	Thousand Dollars	%	Thousand Pounds	%	Thousand Dollars	%
Gulf	1,547,471		268,146		1,772,531		240,836	
Alabama	39,749	2.6	18,080	6.8	36,962	2.1	17,087	7.1
Florida (Gulf)	99,200	6.4	43,462	16.2	104,662	5.9	48,245	20.0
Louisiana	1,035,959	66.9	98,446	36.7	1,228,906	69.3	86,694	36.0
Mississippi	271,594	17.6	16,887	6.3	304,794	17.2	16,355	6.8
Texas	100,969	6.5	91,271	34.0	97,203	5.5	72,455	30.1

Ranking in U. S. (1974) by Landings

State	Catch	Value
Louisiana	1	3
Texas	13	4

Number of Full-Time and Part-Time Commercial Fishermen 1974 2/

State	Full-Time	Part-Time	Total
Louisiana	9,500	4,050	13,550
Texas	6,500	575	7,075

Processing and Wholesale Establishments, 1973

State	Processing Plants	Employment Season	Average Year
Louisiana	118	4,807	3,233
Texas	80	3,430	2,483

State	Wholesale Plants	Employment Season	Average Year
Louisiana	108	489	391
Texas	80	1,491	810

1/ Landings in interior waters are estimated

2/ All data are estimated

Table G-28 (continued)

PLANTS PRODUCING CANNED AND INDUSTRIAL FISHERY PRODUCTS, AND FISH FILLETS AND STEAKS, 1974

State	Canned Fishery Products	Industrial Fishery Products	Fish Fillets and Steaks	Total Plants Exclusive of Duplication
Louisiana	17	23	1	40
Texas	-	1	-	1

Source: U. S. Department of Commerce 1975, Fisheries of the United States, 1974 - Current Fishery Statistics No. 6700

Existing Environmental Quality

Air Quality

Multiple or massive use of air for waste disposal (emissions) in a limited area temporarily degrades the quality (defined as availability for general use) of the air. Evaluation of the potential impact of a proposed additional use of air involves knowledge of the restrictions on additional impacts, the capability of the air to receive additional impacts and the extent of the proposed additional impacts. The remainder of this section examines the first two factors in terms of the legal constraints involved and the existing air quality.

Interstate air quality control regions define areas in which specific controls and standards are applied but which are administered by federal or state jurisdictions. The air quality criteria to be met by a potential pollution source can be complex in that each air quality jurisdiction may have differing criteria. Thus, conceivably, a source in the Houston, Texas, area would have to meet separate criteria imposed by the federal standards (through EPA Region VI), Texas Air Control Board (Texas Region VII), Harris County Division. Table H-1 lists the federal ambient air standards. All individual states are required to adopt standards as stringent as or more stringent than the federal standards. Table H-2 lists the current regulations in force in Texas and Louisiana.

Estimates of air pollution emissions for the counties in the Texas and Louisiana regions have been given in the implementation plans prepared by the various states (Louisiana Air Control Commission (LACC), 1972; and the Texas Air Control Board (TACB), 1973. These data are compiled in Tables H-3 through H-5.

The emission data give quantities of pollutants being emitted into the air, and the air pollution potential gives some indication of the likelihood that the emissions will not be satisfactorily dispersed. Theoretically, air quality data should provide a direct measure of the extent of air pollution in a given area. In fact, coverage is incomplete. Most of the data available are from urban areas, with a few exceptions.

Rather than detail such data as is available at the time of this report, the potential user is referred to the SAROAD system of the Environmental Protection Agency. This provides access to all current and past air quality data, and may be assessed through a specific geographic location.

The quality of air over the proposed area can be degraded from several types of sources including exhaust emissions from stationary power units, service vehicles and by accidental release and combustion of oil or gas. Because of the distance of most of operating facilities in the nearshore tracts air quality degradation could result. To determine the specific effect of emissions on particular areas reference is made to the EPA publication of ''Compilation of Air Pollution Emission Factors'', 1975.

Population and industrial-chemical centers are isolated problem areas. Table H-6 lists the Air Quality Control Regions which have exceeded the national ambient air quality standards. In almost every case, the data are from sampling points located in urban or industrial areas. The trends shown in Table H-6 are based on very limited data. More extensive, although still limited, are the data available from SAROAD. However, the emission estimates in Table H-3 through H-5 are most useful for estimating air quality. Thus, a high carbon monoxide emission level is indicative of high automotive density; and a high hydrocarbon level may indicate petroleum, storage, refining, etc.

The Texas Implementation Plan of 1972 indicated some difficulties in several ACQR's. The following table indicates the priorities assigned to these coastal regions for specific pollutants. Priority I indicates measurements above the primary standards and the requirements for controls to reduce pollutant concentrations.

	Brownsville (213)	Corpus Christi (214)	Houston (216)	South Louisiana (106)
Sulfur dioxide...	III	I	I	I
Particulate........	III	II	I	II
Oxidants..........	III	I	I	I

This information reflects the region classification as submitted in the original Implementation Plan and the semi-annual updates to this plan through August 15, 1975.

Therefore, in lieu of the above data, it is recognized that there is a severe air quality problem along the Texas coast. Since the Texas Implementation Plan of 1972 new and more improved measurement methods have been developed. This allowed for a more accurate recording of the ozone levels in the ACQR's.

Table H-1 AMBIENT AIR QUALITY STANDARDS

Parameter	Standard Primary	Secondary
Particulate Matter:		
Annual geometric mean	75 ug/m^3 1/	60 ug/m^3
24-hour maximum	260 ug/m^3	150 ug/m^3
Sulfur Oxides:		
Annual arithmetic mean	80 ug/m^3	
24-hour maximum	365 ug/m^3	
3-hour maximum	--	1.300 ug/m^3
Carbon Monoxide:		
8-hour maximum	10 mg/m^3 2/	10 mg/m^3
1-hour maximum	40 mg/m^3	40 mg/m^3
Photochemical Oxidants:		
1-hour maximum	160 ug/m^3	160 ug/m^3
Hydrocarbons:		
3-hour maximum	160 ug/m^3	160 ug/m^3
Nitrogen Dioxide:		
Annual arithmetic mean	100 ug/m^3	100 ug/m^3

1/ ug/m^3 = micrograms per cubic meter

2/ mg/m^3 = milligrams per cubic meter

Source: Air Quality Data - 1973 Third Quarter Statistics EPA, 1974.

Table H-2 STATE AMBIENT AIR QUALITY STANDARDS

	Louisiana	Texas
Suspended Particulate Matter:		
Annual geometric mean	1°	1°/11° 1/
Maximum 24-hour mean	1°	1°/11°
Maximum consecutive 5-hour mean	----	100 ug/m^3 (a)
Maximum consecutive 3-hour mean	----	200 ug/m^3 (a)
Maximum consecutive 1-hour mean	----	400 ug/m^3 (a)
Dustfall	20 tons per square mile per month	----
Coefficient of Haze:		
Annual geometric mean	0.6 COH/1000 lin ft	----
Annual arithmetic mean	0.75 COH/1000 lin ft	----
Maximum 24-hour mean	1.50 COH/1000 lin ft	----
Sulfur Dioxide (SO_2):		
Annual mean	1°	1°
Maximum 24-hour mean	1°	1°
Maximum 3-hour mean	----	11°
Maximum 30-minute mean	----	0.4 ppm (b) (c)
Sulfuric Acid Mist: (Sulfur Trioxide, or any combination thereof)		
Maximum annual mean	4 ug/m^3	----
24-hour mean (not 1%)	12 ug/m^3	----
1-hour mean (not 1%)	30 ug/m^3	----
Carbon Monoxide (CO)	1°	1°/11°
Hydrocarbons (other than Methane)	1°	1°/11°
Total Oxidants	1°	1°/11°
Nitrogen Dioxide (NO_2)	1°	1°/11°

1/ 1° and 11° refer to the Primary and Secondary Federal Standards. (a) solid fossil fuel fired steam generators excepted; (b) 0.28 ppm (parts per million) for Harris and Galveston Counties; (c) 0.32 ppm for Jefferson and Orange Counties.

Source: Louisiana Air Quality Control Board, 1974. Texas Air Quality Control Board, 1974.

Table H-3 Air Pollution Emissions Estimates for the Louisiana Gulf Coastal Region

Parish	Emissions in Tons/Year				
	Nitrogen Oxides	Sulfur Oxides	Hydrocarbons	Carbon Monoxide	Particulate Matter
Ascension	---	12,330	13,200	---	534,400
Assumption	---	86	5,960	---	4,360
Calcasieu	---	57,380	55,100	---	7,860
Cameron	---	25	480	---	38
East Baton Rouge	---	35,200	118,300	---	38,080
West Baton Rouge	---	5,980	3,430	---	2,690
Iberia	---	4,760	24,800	---	8,160
Iberville	---	4,660	57,300	---	2,690
Jefferson	---	21,900	20,900	---	6,470
La Fourche	---	220	9,900	---	4,790
Lafayette	---	620	8,700	---	2,460
Livingston	---	110	1,930	---	160
Orleans	---	6,110	24,300	---	7,260
Plaquemines	---	20,800	5,780	---	1,830

(Continued)

Table H-3 (continued)

Air Pollution Emissions Estimates for the Louisiana Gulf Coastal Region (continued)

Parish	Emissions in Tons/Year				
	Nitrogen Oxides	Sulfur Oxides	Hydrocarbons	Carbon Monoxide	Particulate Matter
St. Bernard	---	3,150	2,840	---	680
St. Charles	---	11,300	27,500	---	2,330
St. James	---	26,300	5,250	---	25,700
St. John the Baptist	---	2,170	3,420	---	1,460
St. Martin	---	150	3,870	---	2,440
St. Mary	---	5,340	82,400	---	7,790
St. Tammany	---	220	3,550	---	5,850
Tangipahoa	---	220	3,400	---	750
Terrebonne	---	220	9,140	---	4,450
Vermilion	---	140	1,890	---	400

Source: Louisiana Control Commission: Louisiana Implementation Plan, 1972.

Table H-4 Air Pollution Emissions Estimates for the Texas Gulf Coastal Region

County	Emissions in Tons/Year				
	Nitrogen Oxides	Sulfur Oxides	Hydrocarbons	Carbon Monoxide	Particulate Matter
Aransas		247	5,010	120,660	340
Brazoria	4,395	8,124	116,658	169,006	3,930
Calhoun	1,375	263	23,209	258	9,313
Cameron			12,422	5,174	640
Chambers	70		1,038	3,348	1,710
Galveston	2,558	10,643	65,167	114,128	6,712
Harris	11,962	119,473	156,058	436,418	57,727
Jackson			3,992		420
Jefferson	6,449	71,370	130,366	326,603	11,368
Kenedy			685		
Kleberg			7,616		92
Matagorda	1,715	1	7,225	1,931	820
Nueces	244	2,274	49,736	156,423	4,838
Orange	1,505	4,267	24,157	79,212	5,360

(continued)

Table H-4 (continued)

Air Pollution Emissions Estimates for the Texas Gulf Coastal Region (continued)

County	Emissions in Tons/Year				
	Nitrogen Oxides	Sulfur Oxides	Hydrocarbons	Carbon Monoxide	Particulate Matter
Refugio			660		179
San Patricio		1,409	843	1	5,088
Victoria	1,930		14,122	13,503	211
Willacy			199		744

Source: Texas Air Control Board: Texas Implementation Plan, 1972.

Table H-5 1972 Emissions Inventory Summary -- for Air Quality Control Regions - Texas

	Emissions in Tons/Year				
AQCR	Particulates	Sulfur Oxides	Nitrogen Oxides	Hydrocarbons	Carbon Monoxide
4 Brownsville	8,245	5,747	36,214	52,451	141,650
5 Corpus Christi	35,252	21,634	185,017	299,590	538,416
7 Houston-Galveston	122,468	195,465	399,575	786,359	1,526,593

Table H-6

SUMMARY OF AIR QUALITY CONTROL REGIONS (AQCR)
EXCEEDING NATIONAL AMBIENT AIR QUALITY STANDARDS

Number of Occurrences When Levels Exceeded the Air Quality Standards

POLLUTANTS	AQCR #106 1/			AQCR #213 2/			AQCR #214 3/			AQCR #216 4/		
	1969	1970	1971	1969	1970	1971	1969	1970	1971	1969	1970	1971
SULFUR DIOXIDE												
Annual												
No. greater than the secondary standard (60 ug/m^3 = 0.02 ppm)	0	0	0	0	0	0	0	0	0	0	0	0
No. greater than the primary standard (80 ug/m^3 = ppm)	0	0	0	0	0	0	0	0	0	0	0	0
24-Hour Mean												
No. greater than the secondary standard (260 ug/m^3 = 0.1 ppm)	0	0	0	0	0	0	0	0	0	0	0	0
No. greater than the primary standard (365 ug/m^3 = 0.14 ppm)	0	0	0	0	0	0	0	0	0	0	0	0
3-Hour Mean												
No. greater than the standard (ug/m^3 = 0.5 ppm)	0	0	0	0	0	0	0	0	0	0	0	0

TABLE H-6 (continued) SUMMARY OF AIR QUALITY CONTROL REGIONS (ACQR) EXCEEDING NATIONAL AMBIENT AIR QUALITY STANDARDS

Number of Occurrences When Levels Exceeded the Air Quality Standards

POLLUTANTS	AQCR #106 1/			AQCR #213 2/			AQCR #214 3/			AQCR #216 4/		
	1969	1970	1971	1969	1970	1971	1969	1970	1971	1969	1970	1971
SULFUR DIOXIDE												
Annual												
No. greater than the secondary standard (60 ug/m^3)	4	4	2	1	3	0	0	1	0	4	3	2
No. greater than the primary standard (75 ug/m^3)	0	1	0	1	3	0	0	0	0	3	2	2
24-Hour Mean												
No. greater than the sedondary standard (150 ug/m^3)	0	0	0	2	3	3	0	0	0	1	1	8
No. greater than the primary standard (260 ug/m^3)	0	0	0	2	2	1	0	0	0	0	0	0

TABLE H-6 (continued) SUMMARY OF AIR QUALITY CONTROL REGIONS (AQCR) EXCEEDING NATIONAL AMBIENT AIR QUALITY STANDARDS

NUMBER OF OCCURRENCES WHEN LEVELS EXCEEDED THE AIR QUALITY STANDARDS

	AQCR #106 1/			AQCR #213 2/			AQCR #214 3/			AQCR #216 4/		
POLLUTANTS	1969	1970	1971	1969	1970	1971	1969	1970	1971	1969	1970	1971
CARBON MONOXIDE												
1-hour standard												
No. greater than the standard (40 mg/m^3 = 35 ppm)	0	0	0	0	0	0	0	0	0	0	0	0
8-hour standard												
No. greater than the standard (10 mg/m^3 = 9 ppm)	0	0	0	0	0	0	0	0	0	0	0	0
OXIDANTS												
1-hour standard												
No. greater than the standard (160 ug/m^3 = 0.08 ppm)	0	0	0	0	0	0	0	0	0	0	0	0

* Adapted from Table 309 (EPA, 1973).

ug/m^3 = micrograms per cubic meter.

mg/m^3 = milligrams per cubic meter.

ppm = parts per million (by volume).

1/ Southern Louisiana - Southeast Texas (La.-Texas) (Includes Texas State Reg. 10)

2/ Brownsville-Laredo (Texas) (Includes Texas State Region 4)

3/ Corpus Christi-Victoria (Texas) (Includes Texas State Region 5)

4/ Metropolitan Houston-Galveston (Texas) (Includes Texas State Region 7)

TEXAS

Texas has a severe ozone problem. The standard doesn't allow the ozone level to exceed 0.08 parts per million (ppm) for more than one hour in a calendar year. The majority of the measurements have been made in the upper Gulf Coast area of Texas. This is the region where most of the photochemical industries and metropolitan areas are concentrated.

Ozone concentration vary according to such things as: time of day, season, and weather conditions. During the sunlight hours and the sunny summer months the ozone level increases. Weather also plays a major role in ozone production. High winds usually keep ozone low while relatively stagnant air is conducive to high ozone levels.

The highest ozone level recorded in Texas was 0.42 ppm, measured in August of 1972 in Houston. In every major city in the state where the monitoring of ozone was conducted it showed a high and second high hourly value in excess of the standard of 0.08 ppm at one time or another in the year. However, in the 21,000 hours of monitoring only 700 recordings showed levels in excess of 0.08 ppm. This indicates the total ozone exposure experienced by Texans is low despite the occasionally high levels.

Following is a list of coastal area ozone summaries indicating the second highest ozone hours recorded to date at the various sites.

Location	*Value (ppm)*
Houston	0.256
Olpine	.300
Texas City	.234
Clute	.155
Nederland	.325
West Orange	.195
Corpus Christi	.184

Source: Texas Air Control Board, 1975

Water Quality

The federal agencies responsible for water quality are the Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers. The Corps of Engineers has authority to issue permits for industrial dischargers and dredge disposal areas for marine water bodies. Unfortunately, almost all of the water quality data that has been collected by the Corps has not yet been quantified and is not available in a usable form. The EPA, now the primary federal pollution control agency, is presently issuing discharge permits to industries and municipalities and has begun to quantify the data through its Data Retrieval Program (RAPP). The regional office for the Texas and Louisiana area is Texas (Region VI).

At present, very little data is available from state sources for Louisiana. Most of the data available for this state pertains to point sources of pollution and amount of discharge. Texas has extensive data available, dealing not only with point sources and amount of discharge, but BOD (biochemical oxygen demand), TSS (total suspended solids), etc. The various agencies responsible for water pollution control in Texas and Louisiana are: Louisiana Wildlife and Fisheries Commission, Department of Pollution Control (industrial), and the Louisiana Department of Health, Bureau of Environmental Health, (municipal); and Texas—Texas Water Quality Board and Texas Water Development Board.

Tables H-7 and H-8 summarize water pollution data for all coastal counties of Louisiana and Texas, including such parameters as BOD and TSS for both municipal and industrial sources. In all cases, the amount of discharge per county is expressed in millions of gallons per day (MGD). This figure is merely an expression of the amount of liquid water the discharges in each coastal county are contributing to the Gulf of Mexico or to streams leading to the Gulf. BOD (Biochemical Oxygen Demand) is a measure of the amount (in pounds per day per county) of dissolved oxygen (DO) consumed during the breakdown of organic matter in water by biological processes and organisms. TSS (total suspended solids) is simply an indication of the amount of solid, particulate matter suspended in water and is also measured here in pounds per day per county. Measurements of BOD and TSS are the most widely utilized parameters of water quality polluted because of adverse effects to normally-occurring aquatic organisms.

As can be seen from Tables H-7 and H-8, the areas of heaviest water pollution are, of course, in major metropolitan areas of the coast, and, furthermore, in areas of concentrated petrochemical industries. Other less important sources of water pollution are fish oil processing plants, pulp and paper mills, and foundries and smelters. As might be expected, municipal pollution is a major source of pollution in several major metropolitan areas: Houston, New Orleans and Mobile.

Table H-7 Municipal and Industrial Effluents for Louisiana Coastal Parishes

Parish	Industrial M.G.D. 1/	Municipal M.G.D.
Calcasieu	419.2	10.7
Cameron	0.2	0.2
Iberia	---	0.2
Jefferson	288.0	3.5
La Fourche	266.0	---
Orleans	81.5	80.5
Plaquemines	161.0	3.0
St. Bernard	7.2	12.8
St. Mary	---	4.1
St. Tammany	---	1.3
Terrebonne	0.7	5.6
Vermilion	---	1.2

1/ M.G.D. - million gallons per day

Source: Cooperative Gulf of Mexico Estuarine Inventory and Study, Louisiana, 1971.

Table H-8 Municipal and Industrial Effluents for Texas Coastal Counties

County	Industrial M.G.D. 1/	Industrial B.O.D. 2/	Industrial T.S.S. 3/	Municipal M.G.D.	Municipal B.O.D.	Municipal T.S.S.
Aransas	---	---	---	1.4	564	867
Brazoria	26.40	2,327	1,112	9.9	2,902	2,970
Calhoun	20.10	2,152	15,823	2.3	707	693
Cameron	88.10	2,636	20,678	15.2	8,705	8,243
Chambers	3.90	847	462	.2	86	197
Galveston	125.20	112,767	300,620	15.0	16,283	11,257
Harris	336.00	554,260	555,831	197.4	75,443	128,721
Jackson	---	---	---	.7	130	166
Jefferson	210.00	183,174	130,801	66.0	23,258	12,575
Kenedy	---	---	---	---	---	---
Kleberg	---	---	---	2.1	685	633
Matagorda	6.20	9,846	2,812	2.7	1,215	440
Nueces	197.00	65,106	76,935	28.5	11,825	5,980
Orange	130.20	151,395	91,919	7.3	4,345	1,406
Refugio	.04	1	4	0.9	476	664

(continued)

Table H-8 (continued)

Table Municipal and Industrial Effluents for Texas Coastal Counties (continued)

County	Industrial M.G.D.	Industrial B.O.D.	Industrial T.S.S.	Municipal M.G.D.	Municipal B.O.D.	Municipal T.S.S.
San Patricio	0.30	24	35	3.3	1,753	2,373
Victoria	35.80	6,755	13,010	3.9	951	3,078
Wharton	1.60	34	336	1.8	751	649
Willacy	---	---	---	1.0	76	54

1/ M.G.D. = million gallons per day
2/ B.O.D. = biological oxygen demand, pounds per day
3/ T.S.S. = total suspended solids, pounds per day

Source: Texas Water Quality Board, Texas Water Development Board.

Historical and Projected Economic Growth

Introduction

The areal extent of the industrial and economic effects that may result from this proposed sale are difficult to delineate, due to the fact that the Gulf of Mexico region is a major supplier of crude oil, petroleum products and natural gas to other regions of the United States. The following discussion is limited to the onshore areas adjacent to the proposed lease sale area since the initial economic effects may be assumed to impinge on these sectors.

Additional discussion of the economy in this assessment area has been published by the Bureau of Land Management in the following Final Environmental Impact Statements:

For the Texas area, OCS Sale No. 37 FES 74-63, Vol. 1, pp. 235-313 (USDI, 1975c).
For the Louisiana and Texas area, OCS Sale No. 38, FES 75-37, Vol. 1, pp. 149-212, (USDI, 1975a).
For the Gulf of Mexico region, OCS Sale No. 41, Vol. 1, pp. 309-364 (USDI, 1975b).

The coastal portion of Louisiana will be considered to be the central Gulf of Mexico region and the coastal area of Texas will be considered to be the western Gulf of Mexico region.

The historical changes that have occurred within the economies of these states are summarized in the following passages. These descriptions were based on statistical data provided in the Texas Almanac, 1974-1975 (1975), publications of the Research Department of the Federal Reserve Bank of Atlanta (1972) and supplemented by additional information relating to current economic conditions.

Louisiana

Selected portions of the economic activity for Louisiana are presented in Table I-1. During 1970 approximately 40% of the manufacturing employment in southern Louisiana was in the durable goods industries, and approximately 60% of the employment in manufacturing was in the non-durable goods category.

Approximately 10% of the manufacturing employment in southern Louisiana during 1970 occurred in the metal industries, and almost 19% of the total manufacturing employment was in the category of chemicals and allied products.

Employment in retail trade in the city of New Orleans and including a portion of the adjacent area of the State of Mississippi, amounted to approximately 76,000 persons during 1967, and an additional 31,000 were employed in wholesale trade in the same area.

During October, 1975, the index of employment in manufacturing in Louisiana stood at 104.4 compared to 105.9 during the same period in October, 1974. Employment in the category of construction increased from an index of 99.7 during October, 1974, to 100.2 during October, 1975 (Federal Reserve Bank of Atlanta, 1975).

In the New Orleans Standard Metropolitan Statistical Area (SMSA) including Orleans, Jefferson, St. Bernard, and St. Tammany parishes, the civilian labor force during the month of December, 1975, amounted to 425,500 persons, compared to 418,400 persons during December, 1974. During December, 1975, employment amounted to 391,300 persons, an increase of 4,900 persons over the same month the previous year. However, comparing the unemployment for December, 1975, with December, 1974, reveals that unemployment also increased. During December, 1975, 34,200 persons were classified as unemployed, an increase of 2,200 over the 32,000 persons classified as unemployed during December, 1974.

Texas

Selected portions of the economic activity for Texas are presented in Table I-2.

During October, 1975, approximately 443,000 workers were employed in the manufacture of durable goods, and approximately 365,000 were employed in manufacturing non-durable goods below the levels of October, 1974 in both categories.

Employment in wholesale and retail trade amounted to approximately 951,000 persons in 1972. Employment in water transportation amounted to approximately 21,000, and employment in pipeline transportation amounted to approximately 5,000 during 1972.

The recent changes in the economy of the State of Texas have been summarized by Stockton (1975a).

Comparison of business activity in Texas with measures of business activity on the national level indicated that the Texas economy has shown much greater resistance to the depressing forces present within the national economy than has the nation as a whole. However, the Texas economy did not maintain a normal growth rate.

Table I-1 Economic Activity for Louisiana

	1962	1972
Per capita personal income	$1,764	$ 3,543
Total personal income	$5,901	$13,179 (million)
Total cash farm income	$ 448	$ 882 (million)
Cash farm receipts from crops	$ 264	$ 507 (million)
Cash farm receipts from livestock and products	$ 164	$ 324 (million)
Petroleum production	477	896 (mil. bbls.)
Value of construction	$ 659	$ 2,036 (million)
Manufacturing employment	139	179 (thousand)
Construction employment	53	85 (thousand)

Source: Statistics on the Developing South Federal Reserve Bank of Atlanta - May 1972 and Supplements

Table I-2 Economic Activity in Texas

	1962	1972
Per capita personal income	$ 2,027	$ 4,045
Total personal income	$20,518	$47,121 (million)
Total cash farm income	$ 2,575	$ 3,722 1/ (million)
Cash farm receipts from crops	$ 1,352	$ 1,132 (million)
Cash farm receipts from livestock and products	$ 1,075	$ 2,122 (million)
Petroleum production	943	1,301 2/ (mil. bbls.)
Value of construction	1,132	1,751 1/
Manufacturing employment	497	741 (thousand)
Construction employment	---	238 (thousand)

Source: Texas Almanac 1975-1975. A. H. Belo Corporation.

1/ 1971
2/ Crude production appears to have peaked during 1974.

The most depressed segment of the Texas economy has been the building industry. For the first nine months of 1975 the amount of residential construction declined four percent from the same period in 1974, and residential construction during 1974 was 21 percent below 1973.

Non-residential construction authorizations continue to trail 1974 authorizations in value, but this gap is also narrowing. Major non-residential building categories with increases of 1974 levels include office buildings, hospitals and other institutional structures, and works and utilities.

Employment in the construction industry in Texas amounted to 6.29 percent of the total non-agricultural employment within the state during September, 1975, and ranged from approximately six to 10 percent in selected metropolitan areas (Zlatkovich, 1975).

Employment data is one source of information or change in the individual sectors of the economy although they tend to be rather slow to reflect changes. The changes from a month earlier are not very significant, but employment in durable goods industries declined five percent from a year ago. The decline was rather general, oil field machinery representing the only substantial increase. In non-manufacturing industries, oil and gas extraction showed an increase of seven percent, but contract construction was down six percent. Employment in retail trade rose two percent and in finance, insurance, and estate rose three percent (Stockton, 1975b).

The percentages of unemployed persons reported from selected locations along the Texas coast during the month of October, 1975, are summarized in Table I-3.

The influence of the increased level of petroleum exploration activity both within the state and in other areas, was reflected in various sectors of the Texas economy. Employment in machinery manufacture (excluding electrical) was eight percent higher in February, 1975, than in February, 1974, reflecting largely the increase of 17.5% in employment in oil field machinery manufacture. This is the result of the recent increase in oil exploration. Employment in the manufacture of instruments and related products, which also reflects the effects of oil exploration, increased 5.1% over the past year (Stockton, 1975a).

Employment within Texas in activities related to the oil and gas production and processing industries has also been affected during the past year.

Crude oil production in February, 1975, decreased seven percent compared with February, 1974, as the Texas fields have apparently reached their full capacity for the present. But higher prices of crude oil can be expected to continue; they will undoubtedly support exploration and will add substantially to the economy. Texas employment in oil and gas extraction in February, 1975, showed an increase of 10.5% over the February, 1974 figure, in spite of the fact that the total production of crude oil declined over the same period. The decline in gasoline consumption over the past year is reflected in the 15.1% decline of employment in refining. Some of the decline in refining has been offset by increased activity in chemicals, which are mainly petrochemicals. In spite of the decline in refining, oil and gas continue to be among the major supporting factors for the Texas economy (Stockton, 1975a).

Population and Employment

In 1972, the U.S. Water Resources Council published the 1972 OBERS (Office of Business Economics-Economic Research Service) projections of economic activity in the United States. These projections consist of historical and projected data incorporating population, employment and income and earnings information classified by state and by region. The 1972 projections utilized population projections published by the United States Census Bureau, and were based on the Series C fertility rates. Recently, the projections of economic activity in the various OBERS Economic Areas based on the Series E fertility rates have become available. Projections based on Series E forecast a lower level of population in future years. The following projections for BEA (Bureau of Economic Analysis) areas located within Louisiana and Texas were obtained from the Series E projections.

In considering the coastal portions of Louisiana and Texas during the period 1950 to 1970 the percentage increase in population and employment in these states was greater than the percentage increase in national population and employment. During the period 1970 to 1990, population and employment in the western Gulf of Mexico region is expected to increase at a greater percentage rate than the national percentage rate.

Tables I-4 & I-5 contain population, employment and per capita income data; both historical and projected, for the BEA areas included within Louisiana and Texas.

Table I - 3 Percentages of Unemployed Persons from Selected Texas Coastal Areas

Location	Percent Unemployed October, 1975	Percent Increase From October, 1974
Beaumont-Port Arthur-Orange	9.1	78
Brownsville-Harlingen-San Benito	10.2	19
Corpus Christi	7.3	22
Galveston-Texas City	5.9	40
Houston	5.1	34

Source: Texas Business Review, December, 1975

Table I-4 Regional Population and Employment

Region	1950	1970	Percent Change 1950-1970	1990	Percent Change 1970-1990
Central Gulf BEA Areas: 138 and 139					
Population	2,070,014	2,900,230	40.1	3,142,900	8.4
Employment	692,826	963,028	39.0	1,186,500	23.2
Western Gulf BEA Areas: 140, 141, 142, 143 & 144					
Population	3,140,093	4,883,064	55.5	6,078,000	24.5
Employment	1,133,386	1,816,283	60.3	2,535,700	39.6
United States					
Population	151,325,798	203,235,298	34.3	246,039,000	20.7
Employment	57,474,912	79,306,527	38.0	106,388,000	34.1

Source: OBERS 1972 E Projections

Table I-5 Population, Employment, and Per Capita Income, Historical and Projected 1950-2000
1972-E, OBERS Projections, Bureau of Economic Analysis

E.A	Economic Area	1950	1970	Percent Change 1950-1970	1980	1990	2000
138	New Orleans, La.						
	Population	1,535,505	2,149,598	40.0%	2,284,200	2,440,000	2,528,600
	Per Capita Income	1,641	2,849	73.6%	3,900	5,200	7,000
	Total Employment	530,342	717,945	35.4%	854,000	928,900	1,012,500
139	Lake Charles, La.						
	Population	534,509	750,632	40.4%	695,800	702,900	685,400
	Per Capita Income	1,256	2,463	96.1%	3,400	4,500	6,200
	Total Employment	162,484	245,083	50.8%	251,400	257,600	263,800
140	Beaumont-Port Arthur-Orange, Texas						
	Population	299,857	396,723	32.3%	432,800	484,900	520,100
	Per Capita Income	1,820	3,105	70.6%	4,200	5,500	7,400
	Total Employment	106,986	140,677	31.5%	168,800	192,300	215,800
141	Houston, Texas						
	Population	1,257,035	2,374,842	88.9%	2,832,400	3,362,700	3,780,400
	Per Capita Income	2,308	3,519	52.5%	4,700	6,100	8,000
	Total Employment	485,199	945,995	95.0%	1,244,700	1,474,400	1,701,900

(continued)

Table I-5 (continued) Population, Employment, and Per Capita Income, Historical and Projected 1950-2000
1972-E, OBERS Projections, Bureau of Economic Analysis

BEA	Economic Area	1950	1970	Percent Change 1950-1970	1980	1990	2000
142	San Antonio, Texas						
	Population	853,013	1,235,581	44.8%	1,245,900	1,352,000	1,417,200
	Per Capita Income	1,674	2,770	65.5%	3,800	5,000	6,800
	Total Employment	309,559	451,412	45.8%	503,500	550,300	598,300
143	Corpus Christi, Texas						
	Population	407,011	518,920	27.5%	515,000	534,600	544,000
	Per Capita Income	1,525	2,651	73.8%	3,700	4,800	6,600
	Total Employment	132,095	176,319	33.5%	195,100	204,300	217,400
144	McAllen-Pharr-Edinburg, Texas						
	Population	323,177	356,998	10.5%	346,000	343,800	336,300
	Per Capita Income	1,111	1,884	69.6%	2,800	3,700	5,200
	Total Employment	99,547	101,880	2.3%	113,800	114,400	118,100

1/ Per Capita Income is expressed in 1967 dollars.

The coastal portion of Louisiana and part of Mississippi, comprising the central Gulf of Mexico region, is included with BEA economic areas 138 and 139.

The coastal portions of Texas are included within BEA areas 140, 141, 143 and 144, and are included within the western Gulf of Mexico region.

A comparison of the population, employment and personal income of the inhabitants of these regions with the total United States population, employment and personal income is shown in Table I-6.

Perhaps the most significant relationship revealed in Table I-6 is that in both regions employment and personal income is a smaller percentage of national employment and personal income than is the percentage of population of the total U.S. population.

A significant trend that has been present during the last decade in the economic climate of Louisiana and Texas has been the decline in farm employment and the increase in employment in manufacturing and such non-manufacturing categories as mining, construction, transportation and services.

Table I-7, based on data obtained from the 1972-E OBERS projections, presents the earnings data for selected industries in the Gulf of Mexico regions during 1970.

The BEA economic regions included within classification of western and central Gulf of Mexico form only a portion of the various states bordering the Gulf of Mexico.

Agriculture

During the year 1950, 7,047,625 persons were employed in agriculture in the United States. By the year 1970, 2,813,971 persons were employed in agriculture, and the projected employment in the year 1990 amounted to 2,003,000 persons. The total earnings from agriculture amounted to 19.3 billions of 1967 dollars during 1970, and are projected to amount to 22.6 billions of 1967 dollars in 1900, Table I-8. These projections were contained in the 1972 OBERS projections (U.S. Water Resources Council, 1974) based on the Series E population projections developed by the Bureau of the Census, USDC, 1970. The OBERS projections do not reflect the current energy problem, changes in agricultural exports, or changes in conservation and environmental activities.

The total value of agricultural products within Louisiana and Texas was projected to increase during the period 1959 to 1980, according to the OBERS projections (Table I–9). The total land in farms was projected to decrease in these states during the same period of time. The decrease noted in the total land in farms was in accord with the projection for the entire United States (Table I–10).

During the period 1962 to 1972, the total workers on Texas farms decreased from 415,000 in 1962 to 275,000 in 1972. The total workers include both family workers and hired workers. The total number of family workers decreased from 243,000 to 187,000 and the number of hired workers decreased from 172,000 to 88,000 (A. H. Belo Co., 1973).

These changes in employment reflect post-war changes in Texas agriculture, also reflected in the increase in the average size of Texas farms and increases in the average value of land and buildings on farms and ranches.

The most notable change has been the mechanization of farming due to the increasing use of tractors, mechanical harvesters and other machinery in place of human and animal labor. The introduction and adoption of agricultural chemicals, improved plants and animals, irrigation and increased availability of off-the-farm services have been significant factors in the change of Texas agriculture.

The pattern of decreasing farm employment was also evident in the other states bordering the Gulf of Mexico.

The Petroleum Industry in the Gulf of Mexico Region

Some further discussion of the petroleum industry of Louisiana and Texas is appropriate, since crude petroleum and natural gas production developed as a result of exploration and production activity on the outer continental shelf will probably be a source of raw material for initial processing within the coastal portions of these states.

The production of oil and gas may be classified as a primary industry; the further processing of oil and gas in refineries, natural gasoline plants and petrochemical plants may be considered as secondary industries; and the increased development of tertiary industries may be expected to develop as a result of the economic activity undertaken by the primary and secondary industries.

Table I-6 Population and Employment By Income Regions Compared to Total U. S., 1970

	Total U. S.	Gulf of Mexico Central	Western
Total Population	203,857,864	2,900,230	4,883,064
Percent of U. S.	---	1.4	2.4
Total Employment	79,306,527	963,028	1,816,283
Percent of U. S.	---	1.2	2.3
Total Personal Income1/	$708,583,931	$7,973,192	$15,059,700
Percent of U. S.	---	1.1	2.1

1/ Total personal income in thousands of 1967 dollars.

Table I-7 Total Earnings1/ by Selected Industries, 1970

Industry	Total U. S.	Gulf of Mexico Central	Western
Agriculture, forest & fisheries	19,640,721	226,622	408,029
Mining	5,647,503	407,977	448,490
Manufacturing	156,291,199	1,137,201	2,415,108
Services	85,077,671	884,246	1,792,200
Government	99,310,475	1,073,445	2,350,310

1/ Total earnings in thousands; 1967 dollars

Source: OBERS Projections, Series E.

Table I-8 Total Earnings from Agriculture
(thousands of 1967 dollars)

	1969	1980
Central Gulf of Mexico		
BEA 138	D1/	118,400
BEA 139	D	137,900
Total Central Gulf	D	256,300
Western Gulf of Mexico		
BEA 140	4,440	4,100
BEA 141	D	94,000
BEA 142	127,549	119,100
BEA 143	87,322	81,400
BEA 144	D	96,100
Total Western Gulf	219,311 (partial)	394,700

1/ Deleted

Source: OBERS Projections, Series E, Population

Table I-9 Value of Agricultural Production (shown in 1967 dollars)

State	1959	1980
Louisiana		
Total crops	246,071.4	428,392.0
Total livestock	171,141.9	276,147.3
Total state	417,213.3	704,539.3
Texas		
Total crops	1,071,387.1	1,368,388.7
Total livestock	949,329.8	1,479,583.5
Total state	2,020,716.8	2,847,972.2

Table I-10. Land in Farms (thousand acres)

	1959	1980
United States		
Cropland, harvested	311,285.2	292,242.6
Cropland, not harvested	136,278.5	165,843.4
Forest and woodland	163,684.3	105,231.8
Pasture, range, other	508,909.8	481,566.3
Total land in farms	1,120,157.8	1,044,884.1
Louisiana		
Cropland, harvested	2,425.9	3,747.5
Cropland, not harvested	2,481.1	2,351.7
Forest and woodland	3,212.9	1,634.0
Pasture, range, other	2,227.4	1,868.6
Total land in farms	10,347.3	9,601.8
Texas		
Cropland, harvested	22,236.5	20,331.0
Cropland, not harvested	13,362.6	19,273.8
Forest and woodland	13,631.1	8,624.0
Pasture, range, other	93,987.1	93,338.5
Total land in farms	143,217.5	141,617.3

Source: OBERS Projections, Series E

The coastal region of the states bordering the Gulf, including both onshore and offshore areas, have been producing oil and gas for many years. The production of these hydrocarbons has led to the extensive development of a system of production, transportation, refining and other manufacturing facilities based on the availability of crude and refined petroleum products in the region.

Oil and gas resources include substances classified as crude oil, condensate, natural gas and natural gas liquids. Crude oil is a mixture of hydrocarbons that exists as a liquid in the natural underground reservoir and continues to exist as a liquid on the surface at atmospheric pressure. Condensate is a substance that exists as a gas in the natural underground reservoir and exists as a liquid under atmospheric conditions. Natural gas plant liquids are hydrocarbons extracted from streams of natural gas processed at plants. The American Petroleum Institute and American Gas Association statistical data include as crude oil, small amounts of hydrocarbons recovered from oil well gas that exist as gases in the reservoir but become liquid at atmospheric pressure. All other liquids including condensate are reported as natural gas liquids.

Historical data of Gulf of Mexico OCS operations

Although gas well footage drilled offshore increased 43.3% in the lst quarter of 1975 over the same quarter last year, the exploratory gas well footage declined 11.5% Table I-11). This decline was offset by the increase of 48.2% in developmental gas well footage. Almost three-fourths of the offshore exploratory drilling in the 1st quarter of 1975 took place off Texas, but over 95% of the offshore developmental gas footage occurred off the Louisiana coast.

The number of acres held under active lease in the Gulf of Mexico has increased from 2 million hectares in 1969 to 3 million hectares as of March 31, 1975. Approximately 41% of the acreage held on March 31, 1975, was classified as included in producing leases, compared to 58% so classified in 1968.

The amounts of oil, condensate and gas that have been produced from Federal leases in the Gulf of Mexico are published in Outer Continental Shelf Statistics (USGS, 1975).

The amounts of oil and gas produced from these leases in Louisiana and Texas are tabulated in Table I-12.

Crude oil, gas liquids and natural gas reserves

The estimates of crude oil, gas liquids and natural gas reserves of the five state area adjacent to the Gulf of Mexico as of January 1, 1974, are presented in Table I-13.

Crude petroleum production

During the year 1974, approximately 62% of the total U.S. production of crude petroleum occurred in the states of Louisiana and Texas.

The quantities produced in the coastal area of Louisiana and Texas are shown in Table I-l4.

A significant fact revealed by these statistics is a decline in the production of crude oil and condensate in this region. These decreases occurred in spite of an increase in the average value per barrel of oil.

Recent production figures (Table I-15) indicate that the decline in offshore production was evident during the first nine months of 1975 (U.S. Department of the Interior, 1975b).

Natural gas

The Minerals Yearbook (U.S. Department of the Interior, 1973b), provides statistical detail concerning the source and use of natural gas.

Natural gas produced in Texas during 1971 was used to satisfy the demand for gas by individuals and organizations within Texas and in other areas of the United States During the year 1971, natural gas was also imported from, and exported to Mexico. Some volumes of natural gas produced in other states were transported into Texas during the year.

Approximately 90% of the natural gas withdrawn from Texas wells was marketed. The balance was used for repressuring and a small amount was vented to the atmosphere or flared. The marketed production of Texas natural gas, augmented by volumes obtained from other areas, was delivered to interstate pipelines for transmission to other areas, consumed in Texas or added to storage. Some amounts of gas were lost in transmission. Approximately 51% of the total Texas receipts of natural gas were consumed in Texas.

Some of this gas was used for lease and plant fuel and pipeline fuel, but approximately 72% was delivered to consumers, including residential and commercial users, electric utilities and industrial establishments. The industrial uses of the natural gas included fuel for refining operations, feed-

Table I-11 NEW WELL AND COMPLETION DATA ON THE FEDERAL OCS, GULF OF MEXICO

Year	Oil & Gas New Well Starts	Oil & Gas Well Completions	Zone Completions Producible Oil and Gas Zones Oil	Gas	Total
1968	931	410	524	166	690
1969	826	363	448	125	573
1970	827	535	611	266	877
1971	806	379	357	240	597
1972	839	335	303	180	483
1973	816	418	302	288	590
1974	808	305	221	155	376

Source: Federal Power Commission News, August 8, 1975.

Table I-12 OIL AND CONDENSATE (thousand bbls)

Year	Louisiana	Texas	Total
1968	263,825	3,111	266,936
1969	300,159	2,760	302,919
1970	333,411	2,247	335,658
1971	385,760	1,685	387,445
1972	387,591	1,733	389,324
1973	374,197	1,618	375,815
1974	342,435	1,382	343,817

NATURAL GAS MMCF

Year	Louisiana	Texas	Total
1968	1,413,468	109,911	1,523,379
1969	1,822,544	127,097	1,949,641
1970	2,273,147	133,300	2,406,447
1971	2,634,014	127,358	2,761,372
1972	2,881,365	147,156	3,028,521
1973	3,055,628	148,674	3,204,302
1974	3,349,171	159,979	3,509,150

Source: Outer Continental Shelf Statistics, U.S.G.S
June, 1975

Table I-13 ESTIMATED CRUDE OIL, NATURAL GAS LIQUIDS AND NATURAL GAS RESERVES 1/

State	Crude Oil Thousands of Barrels	Natural Gas Liquids Thousands of Barrels	Natural Gas MMCF
Louisiana	4,576,826	1,992,537	69,151,613
Texas	11,756,613	2,830,143	84,936,502

1/ These totals represent approximately 48, 76, and 62 percent, respectively of the total U.S. reserves as of January 1, 1974.

Source: American Petroleum Institute, et al. (1975), estimates as of January 1, 1974.

Table I-14 Production, Producing Wells and Average Production Per Well

	1974	1973
Louisiana (Gulf Coast)		
Crude Petroleum Production 1/	698,488	791,760
No. Producing Oil Wells	12,858	13,086
Average Production Per Well 2/	147.5	162.4
Average Value Per Barrel	\$6.52	\$4.00
Texas (Gulf Coast)		
Crude Petroleum Production	246,586	253,296
No. Producing Oil Wells	14,257	14,199
Average Production Per Well	47.5	46.6
Average Value Per Barrel	\$7.41	\$4.11
United States (Total)		
Crude Petroleum Production	3,202,585	3,360,903
No. Producing Oil Wells	497,631	497,378
Average Production Per Well	17.6	18.3
Average Value Per Barrel	\$6.74	\$3.89

1/ Thousands of barrels

2/ Average production per well per day (barrels)

Source: U. S. Department of the Interior (1975a).

Table I-15 Crude Oil and Condensate Production for Texas and Louisiana Offshore Areas (thousands of bbls.)

	1972	1973	Jan-Sept. 1975	Jan-Sept. 1974
Louisiana Gulf Coast Offshore				
State	78,693	53,298	29,920	57,972
Federal	318,423	373,486	241,160	249,773
Total Offshore	397,116	426,784	271,080	307,745
Texas Gulf Coast Offshore				
State	577	669	251	457
Federal	504	728	318	385
Total Offshore	1,981	1,397	569	842

Source: U. S. Department of the Interior, 1975c.

stock for the chemical industry and as material for the manufacture of carbon black.

During the year 1974 the total marketed production of natural gas in the United States amounted to 21,600 billion cubic feet (612 billion cubic meters), a decrease percentage from the 1973 level. The marketed production in the states of Louisiana and Texas amounted to 15,924 billion cubic feet, (451 billion cubic meters), approximately 74 percent of the total marketed production, Table I-16.

Net deliveries of natural gas to interstate pipelines during 1974 amounted to approximately 5,526 billion cubic feet (157 billion cubic meters) from Louisiana and 3,229 billion cubic feet (91 billion cubic meters) from Texas. Consumption of natural gas in Louisiana and Texas amounted to approximately 7,115 billion cubic feet (202 billion cubic meters) during 1974, approximately 32% of the total U.S. consumption during the year (USDI, 1974g).

The number of producing and condensate wells located in these states decreased from 34,356 to 33,894 between December 1973 to 1974.

The Federal Power Commission News, (1973), in a review of aspects of the natural gas supply in the United States, remarked on the recovery of gas well drilling activity that began in 1972 and continued during 1973 until capacity bottlenecks occurred toward the end of the year. The review continued an analysis of the current supply situation. ''In contrast, the shortage of gas supply for ultimate consumers became more acute during 1973. For the past three years both marketed production of natural gas and producer sales to interstate pipelines have fluctuated within a very narrow range. Between 1972 and 1973 marketed production declined by 0.3% and producer sales (FPC Form 11 reports) declined by 2.9%. In the previous year there were increases of 0.2% in marketed production and 1.3% in producer sales. It is thus apparent that the new reserves that have become available as a result of increased gas well drilling have not been sufficient to prevent a further worsening of the national gas shortage. During the past year or two, some pipelines were unable to acquire enough new reserves to offset the declining production from old wells, let alone meet the obvious need of all pipelines for more gas to serve the increased demand created by growth in the economy.''

Employment in Offshore Petroleum Activities

The Department of Commerce publications, 1972 Census of Mineral Industries, provide data on mining operations concerned with the extraction of solids, liquids, and gases.

For oil and gas field operation and contract services, reports were required for units somewhat different from the ''establishment'' reporting unit used for other types of mining. Every concern which operated oil and gas wells or performed oil and gas field services for others during any part of calendar year 1972 was required to submit a separate report for each state, or offshore area adacent to a state.

Industries were classified in accord with the definitions established in the 1972 Standard Industrial Classified Manual. This system developed over a period of years by experts from government and private industry under the guidance of the Office of Management and Budget.

Industry 131, Crude Petroleum and Natural Gas, represents establishments primarily engaged in operating oil and gas field properties. Such activities include exploration for crude petroleum and natural gas; drilling, completing, and equipping wells; operation of separators, emulsion breakers, desalting equipment; and all other activities incident to making oil and gas marketable up to the point of shipment from the producing property. The data published for this industry include figures for administrative offices, warehouses, storage facilities, and other auxiliary units which service mining industries. For the crude petroleum and natural gas industries, details were obtained on the type of wells drilled and operated and reports were classified on the basis of whether or not they drilled wells. No drilling data or wells-operated data were obtained or estimated for companies with less than five paid employees. While these small companies account for a small percentage of value added in the oil and gas industry, they do engage in significant drilling activity and they also operate a large number of wells.

SIC Industry Group 138, Oil and Gas Field Services, includes three principal industries. Industry 1381, Drilling Oil and Gas Wells, represents establishments primarily engaged in drilling wells for oil or gas for others on a contract, fee or other basis. This industry includes contractors that specialize in spudding in, drilling in,

Table I-16 Natural Gas Production and Consumption (million cubic feet)

	1973	1974
Gross Withdrawals		
Louisiana	8,491,194	7,919,810
Texas	9,289,945	8,170,798
Total	17,781,139	16,090,608
Marketed Production		
Louisiana	8,242,423	7,753,631
Texas	8,513,850	8,170,798
Total	16,756,273	15,924,429
Consumption		
Louisiana	2,216,692	2,202,693
Texas	5,087,521	4,912,481
Total	7,304,213	7,115,174
Net Deliveries to Interstate Pipelines		
Louisiana	5,905,857	5,526,285
Texas	3,390,531	3,742,066
Total	9,296,388	8,755,922

Source: U. S. Department of the Interior (1974g).

redrilling, and directional drilling. Industry 1382, Oil and Gas Exploration Services, represents establishments primarily engaged in geophysical, geological, and other exploration work on a contract, fee or other basis.

Industry 1389, Oil and Gas Field Services, N.E.C. represents establishments primarily engaged in performing for others on a contract, fee, or other basis, such oil and gas field services as excavating, grading and building foundations, surveying, well cementing, well treating, and running, cutting, and pulling casing, tubes and rods.

SIC Industry Group 132, Natural Gas Liquids, represents establishments primarily engaged in producing liquid hydrocarbons from oil and gas field gases. Establishments recovering liquified petroleum gases incident to petroleum refining or to the manufacturing of chemicals are classified in Major Groups 28 or 29, are therefore not included within this group.

Data published in the applicable volumes of the 1972 Census of Mineral Industries reveal the historical changes in establishments, employees and payrolls in these industrial categories in the United States, Table I-17.

During the year 1972, the number of employees within SIC 138 were further classified into membership within SIC 1381, Drilling Oil and Gas Wells; SIC 1382, Oil and Gas Exploration Services, and SIC 1389, Oil and Gas Field Services NEC.

Table I-18 provides a summary of the employment within the oil and gas exploration and production related industries during the year 1972.

During the year 1972, the total of all employees included within the U.S. total number of employees amounted to 240,500 persons. The total number of employees classified as working on offshore activities was 14,400 persons, approximately six percent of the total national employment in these industry groups. The total employment associated with the Louisiana offshore amounted to 11,900 persons, approximately five percent of the total national employment and 83 percent of the total national offshore employment.

Comparison of offshore employment levels between 1967 and 1972 for the West South Central Division includes the offshore areas adjacent to the states of Texas and Louisiana, Table I-19.

Petroleum Refining and Petrochemical in the Coastal Zone

On January 1, 1975, the crude oil capacity of the operating petroleum refineries in the United States amounted to 14,980,550 barrels per calendar day (BCD). The total operating refinery capacity in the refineries along the coast of Texas and Louisiana amounted to 5,117,950 BCD or approximately 34% of the total U.S. capacity, Table I-20.

Additional crude oil refining capacity amounting to 615,550 BCD was under construction in the coastal areas of Louisiana and Texas.

Petroleum refining industry of Texas

As of January 1, 1974, according to the annual refining survey published in the Oil and Gas Journal (January 1, 1974), there were 24 operating petroleum refineries in the Texas coastal region with a combined capacity of more than three million barrels per calendar day.

The Texas Gulf coast refining district is the largest domestic refining district, measured in crude oil throughout capacity, and accounted for approximately 23% of the total operating crude oil throughout capacity of the United States (including Puerto Rico) (USDI, 1973f).

During the period 1962 to 1973, the daily crude oil capacity in the Texas Gulf coast district increased by 846,400 BCD, an increase of approximately 39% over the 1962 operating capacity. The raw material received at refineries in the Texas Gulf coast refining district includes crude oil from domestic and foreign sources, natural gas liquids and other hydrocarbons. The products produced by refineries include gasoline and other fuels, lubricating oils, wax, coke, asphalt and feedstocks for petrochemical plants.

Refineries in Texas receive crude oil from other states for processing and some of the crude oil produced in Texas is shipped to other states for refining.

During the year 1973, a total of 1,174 billion barrels were received at refineries in Texas. Approximately 1,045 billion barrels were obtained from sources within the United States, and an additional 128.8 million barrels were obtained from foreign sources. This level of imports is approximately equal to 350,000 BCD, (USDI, 1974).

Petrochemical industry

The importance of the chemical industry to Texas was recently evaluated by Ryan (1973).

Table I-17 Exploration and Production Employees - 1972

Year	SIC 1311	SIC 1321	SIC 138
	Number of Employees (thousands)		
1954	172.5	17.3	125.9
1958	180.1	16.5	116.3
1963	145.2	13.9	112.4
1967	126.4	12.4	106.4
1972	116.6	10.7	113.2
	Number of Establishments		
1954	11,508	562	5,515
1958	12,010	593	5,915
1963	14,378	652	6,212
1967	8,796	684	6,878
1972	7,605	680	6,209
	Payroll (millions of dollars)		
1954	835.7	85.1	541.6
1958	1,043.1	96.3	561.3
1963	1,016.4	96.6	631.7
1967	1,049.1	99.5	706.5
1972	1,376.0	116.8	1,032.9

Source: Census of Mineral Industires (1972)
Bureau of the Census

Table I-18 Employees in Offshore Operations

Industry	Total U.S.	Total Offshore	West South Central Region	Total Louisiana	Louisiana Offshore	Total Texas	Texas Offshore	Other Offshore California	Other Offshore Alaska
All Employees (thousands) 1972									
131 - 1311	116.6	5.3	77.7	20.0	4.0	46.7	0.3	0.7	0.3
132 - 1321	10.7	N.D.	8.1	1.7	N.D.	5.1	N.D.	N.D.	N.D.
138 - 1381	45.2	5.1	29.3	11.4	4.6	13.7	0.5	N.D.	N.D.
138 - 1382	9.8	0.2	5.7	0.8	0.1	4.2	N.D.	N.D.	N.D.
138 - 1389	58.2	3.8	40.1	12.3	3.2	18.7	N.D.	N.D.	N.D.
Production, Development and Exploration Workers (thousands) 1972									
131 - 1311	51.9	3.7	30.8	9.5	3.0	16.1	0.2	0.4	0.1
132 - 1321	8.9	N.D.	7.0	1.4	N.D.	4.5	N.D.	N.D.	N.D.
138 - 1381	40.1	4.5	25.6	10.0	4.0	11.9	0.5	N.D.	N.D.
138 - 1382	7.8	0.1	4.3	0.7	0.1	3.1	N.D.	N.D.	N.D.
138 - 1389	45.5	3.2	31.0	10.0	2.7	15.1	N.D.	N.D.	N.D.

Note: N.D. means No Data.
Industry 1311 - Primarily engaged in operating oil and gas field properties.
Industry 1321 - Primarily engaged in producing liquid hydrocarbons from oil and gas field gases.
Industry 1381 - Primarily engaged in drilling oil or gas wells for others on a contract, fee, or similar basis.
Industry 1382 - Primarily engaged in performing geophysical, geological and other exploration services on contract or fee.
Industry 1389 - Primarily engaged in performing miscellaneous oil and gas field services.

Table I-19 Number of Employees (thousands)
West South Central Division

Industry	1972	1967
131 - 1311	4.3	2.3
132 - 1321	N.D.	N.D.
138 - 1381	5.1	4.4
138 - 1382	0.1	0.4
138 - 1389	3.2	2.1

Source: Census of Mineral Industries (1972)
Bureau of the Census

Table I-20 LOUISIANA COASTAL OIL REFINERIES

Operating Refineries	Location	Crude Oil Capacity B/CD
Canal Refining	Church Point	3,750
Cities Service	Lake Charles	268,000
Continental Oil	Egan	15,000
Continental Oil	Westlake	83,000
Evangeline Refining	Jennings	4,600
Exxon	Baton Rouge	445,000
Good Hope Refineries	Good Hope	29,450
Gulf Oil	Belle Chase	180,400
Gulf Oil	Venice	28,700
La Jet	St. James	11,000
Murphy	Mereaux	92,500
Placid Refining	Port Allen	36,000
Shell	Norco	240,000
Tenneco	Chalmette	103,000
Texaco	Convent	140,000
Total Operating		1,680,400
Capacity Additions under Construction		
Exxon	Baton Rouge	15,000
Good Hope Refineries	Good Hope	20,050
		35,050
Refineries under Construction		
ECOL, Ltd.	Reserve	200,000
Total Capacity under Construction		235,050

Table I-20 (continued)

Texas Coastal Refineries Operating		Crude Oil Capacity Barrels/Cal. Day
American Petrofina of Texas	Port Arthur	84,000
Amoco Oil Co.	Texas City	333,000
Atlantic Richfield Co.	Houston	213,000
Champlin Petroleum Co.	Corpus Christi	67,700
Charter International Oil Company	Houston	70,000
Coastal States Petro-chemical Co.	Corpus Christi	185,000
Crown Central Petroleum Corp.	Pasadena	100,000
Eddy Refining	Houston	3,250
Exxon Co.	Baytown	400,000
Gulf Oil Corp.	Port Arthur	312,100
Marathon Oil Co.	Texas City	64,000
Mobil Oil	Beaumont	335,000
Monsanto Chemical	Alvin	8,500
Phillips Petroleum	Sweeney	85,000
Quintana-Howell	Corpus Christi	30,000
Shell Oil Co.	Deer Park	294,000

Table I-20 (continued)

Total Operating and Under Construction		1,915,450
South Hampton Co.	Silsbee	18,100
Southwestern Refining Co.	Corpus Christi	114,000
Sun Oil Co.	Corpus Christi	57,000
Texaco	Port Arthur	406,000
Texaco	Port Neches	47,000
Texas City Refining	Texas City	74,500
Union Oil Co. of California	Nederland	127,000
Union Texas Petroleum	Winnie	9,400
		3,437,550

Texas Coastal Refineries

Capacity Additions (under construction)

American Petrofina of Texas	Port Arthur	34,000
Atlantic Richfield Co.	Houston	92,000
Exxon Company	Baytown	250,000
Mid-Tex Refinery	Hearne	4,500
		380,500
Total Capacity (Operating and Under Construction)	-	3,818,050

Louisiana and Texas Totals

State	No. of Refineries	Crude Oil Capacity (B/CD)
Louisiana (coastal area) Operating	15	1,680,400
Under Construction	1	235,050
Total	16	1,915,450

Table I-20 (continued)

Texas (coastal area)		
Operating	24	3,437,550
Under Construction	-	380,500
Total	24	3,818,050
Texas and Louisiana Totals		
Operating	39	5,117,950
Under Construction	1	615,550
Total	40	5,733,500

Source: Petroleum Refineries Annual
Bureau of Mines
January 1, 1975

Chemical production is Texas' top-ranking industry as measured by value added by manufacture (the difference between the cost of raw materials and the value of products). In 1973, more than 61,000 workers were employed in chemical plants; the output value in 1970 totaled $4.8 billion. The most important product group is industrial organic chemicals, the basic materials from which synthetic fibers and plastics, rubber, lubricants and hundreds of other products are made.

Late in the year 1972, a survey revealed that 622 petrochemical plants were operating within the United States. Of this total number of plants, approximately 22% were located in Texas. More than two-thirds of the plants representing almost 90% of the producing capacity were located in the coastal zone of Texas. During the period 1950-59; 21 plants commenced operations; during the period 1960-69; 17 plants went on stream.

The most important reason cited for the growth of the petrochemical industry in Texas is "nearness to raw materials". Other factors influencing the development of this industry have included the availability of an existing facility; the availability of transportation, labor and land, and nearness to markets.

PETROLEUM RELATED INDUSTRIES IN LOUISIANA

The following description of some of the important industries in the Louisiana coastal zone was published in the Louisiana Advisory Commission on Coastal and Marine Resources (1973a). The following description of the more important industries in the coastal zone parishes by the Louisiana Department of Commerce and Industry was presented in a report to the Commission in February, 1972.

Industry in the coastal region is dominated by petroleum refining, petrochemical production, ship and boat building, food processing and primary metals. Apparel making, metal fabrication, and pulp and papermaking are also important industries. Petroleum refining and petrochemicals are by far the largest. More than $5 billion has been invested in these industries in the coastal region since World War II and most of these 32,000 plus workers employed in these industries work in the coastal parishes. There are approximately 100 major petroleum and petrochemical plants in Louisiana making the state one of the principal producers in the United States. A number of the facilities are among the largest of their kind in the world. Over the last 10 years Louisiana has attracted about 10% of all new investment in chemical and petroleum refining expenditures in this country.

Ship and boat building continue to be a mainstay in the state's industrial economy. A shipyard is the single largest employer in Louisiana, with a work force ranging upward to 10,000 at times. The Avondale yards and other smaller yards specialize in supplying the needs of the offshore oil and gas industry with drilling platforms, tugs, barges, crewboats and other specialized vessels that are constructed in Louisiana. Boats for commercial fishing and pleasure use are built in small yards scattered across the coastal region.

Specific areas within Louisiana with important concentrations of refineries and petrochemical plants include Baton Rouge, New Orleans and Lake Charles. The Lower Mississippi Region Comprehensive Study includes descriptions and projections for significant economic and industrial factors. Water Resource Planning Area (WRPA) includes 10 Louisiana parishes and Amite County, Mississippi, and includes the Baton Rouge area. An economic description of this area emphasizes the importance of the Baton Rouge industrial development.

Baton Rouge, the capital of Louisiana, is a major center of petroleum and chemical industries. It is situated on the Mississippi River 322 km from the Gulf of Mexico at the head of navigation for ocean-going vessels. The total value of industrial investment along the banks of the Mississippi River in WRPA 8 since 1946, has been $1.9 billion ($0.6 billion between 1946 and 1960, and $1.3 billion between 1961 and 1971). In 1967, East Baton Rouge Parish accounted for 81% of the area's $564.1 million value added by manufacturing. Petroleum refineries, the industrial base of the city, are supplied by nearby oil fields in south Louisiana. Many plants in the city either supply refinery needs, further process refinery products, or are engaged in related work.

Water Resource Planning Area 9 included a 14 parish area extending from the border with Texas to the basin of the Atchafalaya River, bordering the Gulf of Mexico. WRPA 9 is rich in oil, natural gas, salt, sulfur, sand, gravel and clays. The development of oil and natural gas resources has contributed more than any other factor to the progress of the area and to the rapid strides made in the raising of living standards and industrial

growth. Oil and gas fields are located throughout the area as well as offshore in the Gulf of Mexico. Salt deposits are located on the eastern and western borders and sulfur is mined in Calcasieu Parish.

A combination of varied natural resources, water access, geographical location, road and rail connections has made WRPA 9 an attractive location for industrial firms. The extent and quality of these resources are attested to by some of the Nation's major chemical producers having developed a multi-million-dollar petrochemical complex around Lake Charles. Natural resources have also been of great importance to Lafayette, Louisiana, as it has become the area headquarters and service center for the oil and gas industry. Industrial growth has also been enhanced by the existence of the deepwater port of Lake Charles.

Water Resource Planning Area 10 includes Jefferson, Orleans, St. Bernard and St. Tammany parishes. Due to the presence of varied natural resources and its location on crossroads of internal and foreign commerce, WRPA 10 has experienced remarkable industrial development. A vast complex of petrochemical plants has been developed in recent years along the Mississippi River. Other industries have grown up around such native resources as sulfur, salt, sugar and imported products such as bauxite, gypsum and coffee have also contributed to industrial development.

Transportation of Oil and Products.

During 1974, refineries in Texas and Louisiana received crude oil from producing wells in the same state as the refinery location, from producing wells in other states and imported crude oil from foreign nations, Table I-21.

Pipeline transportation is important in providing means for the delivery of crude petroleum to refineries in the four state area.

Table I-21 TRANSPORTATION OF CRUDE OIL IN 1974
(thousands of barrels)

Area	Pipelines	Tank Cars & Trucks	Tankers & Barges	
Louisiana				
Domestic crude	415,079	5,084	96,370	
Foreign crude	---	---	16,510	
Texas				
Domestic crude	920,773	9,619	115,054	
Foreign crude	---	---	128,872	
			211,424	Domestic crude
Total	1,335,852	14,703	145,382	Foreign crude

Source: United States Department of the Interior, 1974i.

Table I-22 WATER TRANSPORT OF CRUDE OIL AND PRODUCTS
(thousands of barrels)

	1974 January to May	1973
Gulf Coast to East Coast		
Crude oil	30,513	29,620
Unfinished oils	9,301	6,998
Products	155,515	183,098
Totals	195,329	219,696
Gulf Coast to P.A.D. District II		
Crude oil	4,871	4,365
Unfinished oils	8	18
Products	26,557	27,538
Totals	31,436	31,921
Gulf Coast to West Coast		
Crude oil	564	---
Unfinished oils	---	113
Products	5,371	638
Totals	5,935	751

Source: United States Department of the Interior, 1974.

Future Environment Without the Proposal

It is important that the future environment of the Gulf of Mexico be examined in the event that the proposal does not occur.

The addition of the oil and gas produced as a result of this sale to the quantities of oil and gas currently being produced on the outer continental shelf in the Gulf of Mexico can be expected to continue the use of facilities installed for the transportation and processing of oil and gas reserves developed from previous state and federal offshore lease sales.

Production developed in onshore areas prior to, concurrent with and subsequent to production developed in the offshore areas also required production, transportation and processing facilities. In the event that this proposed sale was not held, it is considered probable that the skilled and unskilled labor, specialized equipment and other facilities that would be employed in the development of leases awarded as a result of proposed Sale 44 would be employed in the specialized activity of exploring for, producing, processing and transporting oil and gas in an alternate area.

The resultant economic and environmental impact of these activities in other areas can not be known at this time, as it would be necessary to delineate these areas in a precise fashion in order to estimate these impacts. It is possible that the resources would be employed in the onshore areas adjacent to the offshore areas; in which case, the economic impact would be similar to the impact anticipated to result from this proposed sale.

Given the extensive development of industries supporting the offshore production of oil and gas, and the extensive development of industries related to the processing of oil and gas, additional supplies of oil and gas from any source in the Gulf of Mexico area are likely to be processed within existing facilities in the area.

It is probable that industry interest in the OCS indicates that larger quantities of oil and gas may be obtained for a given investment dollar. If this speculation is valid, it suggests that outer continental shelf production is efficient in the economic sense, in that a larger return can be anticipated from a smaller expenditure of scarce resources.

A further observation governing the continued operation of the refining industry, and industries utilizing the products of refineries may be in order. It is probable that existing refineries within the Gulf of Mexico coastal area will continue to operate as long as demand for the products continue. In the event that sufficient feed stock is not available, imported crude oils will be utilized. According to the Federal Energy Administration (1975) imports of crude oil amounted to approximately 3.9 million barrels per day, compared to domestic production of an estimated 8.5 million barrels per day during December, 1974.

The environmental effects of additional onshore production, and/or additional crude oil imports to the existing refining centers, must be considered in determining the status of the future environment of the Gulf of Mexico region in the event that this proposed lease sale is not implemented.

ENVIRONMENTAL IMPACTS OF THE PROPOSED ACTION

Much of the impact data on which this section was based, was generalized, incomplete and not specific to the Gulf of Mexico. In many cases, impact estimates were determined by extrapolating from such data. Where such data was reasonably sufficient, the magnitude and importance of such impacts have been identified. However, no attempt was made to make conclusive and quantified impact estimates if the data base was considered inconclusive. Such impacts were discussed generally and speculatively.

Basic Assumptions Regarding Causes of Impacts of the Proposed Action

Should development follow this proposed sale, it will impact the natural and socioeconomic environments of the Gulf of Mexico area. To identify impacts and assess their magnitude and significance, it is necessary to project certain basic assumptions as follows:

Disposal of Cleaned Drill Cuttings and Commercial Muds

Drill cuttings are composed of shattered and pulverized sediments and underlying native rock. Drill cuttings range from about 195 to 244 cubic meters for a 3,048 meter well to about 260 to 341 cubic meters for a 4,267 meter well, with about 228 to 293 cubic meters for the average 3,658 meter well (USGS, 1976).

Assuming 25 to 75 exploratory wells and 100-300 production wells in the proposed sale area, 28,500 to 109,875 cubic meters of cuttings will be dumped adjacent to the platforms (USGS, 1976).

The common components of the drilling mud which will be discharged are identified in Table A-1. This discussion is based on the representative well-drilling mud program, but other components could be added in special cases. Some 28,750 to 86,250 tons of commercial drill muds will be used in drilling this number of wells (USGS, 1976).

Present mud technology does require that mud be disposed in order to change the characteristics or chemistry necessary for changing conditions as a well is drilled deeper (USGS, 1976). If there is any mud left over from one well, it can be reused in the following well. It is common industrial practice to reuse or recycle drilling mud and the high cost of drilling mud components provides the incentive to continue this practice.

Some drilling mud, however, will be introduced into the marine environment but there must be compliance with the OCS Operating Orders. Minor quantities of drilling mud may be discharged (1) with the drill cuttings; (2) when cleaning shale or sand tanks (settling tanks); (3) while drilling the upper portion of the hole prior to establishing circulation to the drilling platform; and (4) upon disconnection of a marine riser. The last two cases apply only to operations from floating drilling platforms and not to jack-up or fixed production platforms.

It is estimated that about 10% of the total volume of drilling mud may be discharged into the ocean environment (USGS, 1976). Based on this 10% figure, the range of volume that might be discharged into the marine environment would be 2,875 to 8,625 tons.

Of some concern is the presence of chromium in some marine drilling muds such as the organic complex (ferro) chrome lignosulfonate. Overboard loss or discharge of drilling fluids would introduce some of this chromium into the marine environment. Overall recent industrial tendencies toward maximum recovery of chemical additives minimize any potential hazard to marine life.

The use of chrome materials, oil and other toxic materials in the Gulf offshore mud systems has been avoided for several years. Sodium lignosulfonate has replaced ferro chrome lignosulfonate in a majority of the Gulf offshore mud systems. Barium sulfate (barite) and chromium lignosulfonate are commonly used compounds found in offshore drilling mud programs in the Gulf of Mexico OCS.

Barite is used as a weighing agent to control formation pressures while drilling in the mid to bottom portions of the hole. Chromium lignosulfonates are thinners which are placed into a mud system for control of viscosity, gel strength, and filtrate loss. They are also introduced into the mud system while drilling from the mid to bottom portions of the hole. There is strong environmental concern about products containing barium and chromium due to the possibility of the release into the environment of the toxic Ba^{+2} and hexavalent Cr^{+6} ions.

Barite has been used in the Gulf of Mexico drilling mud programs since the inception of drilling in 1947. The data from several investigations have shown barite to be essentially nontoxic to marine organisms. The threshold of LC_{50}

TABLE A-1

Components of Drilling Muds Which Are Normally Discharged into the Sea

Substance	Source	Use	Composition	Known Hazard
Attapulgite clay	Quarry	To cause gelling of salt water based muds	A light green magnesium-rich clay, quarried as "Fuller Earth"	NONE
Bentonite clay	Quarry	To cause gelling of freshwater based muds	A light-colored mont-morillonitic clay; slippery sticky when wet; swells to 10-20 times its dry volume	NONE
Caustic soda	Electrolysis of sodium chloride brine	For pH control	Sodium hydroxide, NaOH	Corrosive in concen-trated form; not harm-ful after mixing into mud at low concentration and allowed to react
Ferrochrome lignosulfo-nate	Digestion of wood by sul-fonate process removal of cellulose; reaction with chromium com-pounds	Dispersant and emulsifier	Ferrochrome salt of lignosulfonic acid; content: Fe-2.6%, Cr-3.0%, S-5.5%	Possible chromium toxi-city in pure form, none known from diluted form in muds
Organic polymer	Chemical pro-cess with plant starch, wood fiber as raw materials	Conditioner, texturizer	Starch, cellulosic derivatives	NONE

TABLE A-1 (continued)

Components of Drilling Muds Which Are Normally Discharged into the Sea

Substance	Source	Use	Composition	Known Hazard
Proprietary defoamer	Soap making process	Defoamer	Aluminum stearate $Al[Ch_3(Ch_2)16]3$	NONE
Barite	Mined as the mineral	Weighting agent	Barium sulfate $Ba\ SO_4$	It is recommended that public water supplies contain no more than 1 mg/1 barium
Gypsum (Plaster of Paris)	Mined as the mineral	Flocculantand calcium source	Calcium sulfate $CaSQ_4.2\ H_2O$	Potentially hazardous
Tennin	Extracted from the Quebracho tree	Thinning agent	Complex organic compound, $5(C_{14}H_9O_9).C_6H_7O$	NONE
Carboxymethyl cellulose	From stalks and stems of plants	Fluid loss agent	Complex organic polymer	Potentially hazardous
Sodium acid pyrophosphate	Reaction of sodium with pyrophosphoric acid	Thinning agent	$Na_2H_2P_2O_7$	NONE
Siderite	Mined as the mineral	Weighing agent	$FeCO_3$	NONE

TABLE A-1 (continued)

Components of Drilling Muds Which Are Normally Discharged into the Sea

Substance	Source	Use	Composition	Known Hazard
Formaldehyde	Oxidation of methanol	Bactericide	HCHO	Potentially hazardous
Penta	Reaction of hexachloro-benzene with sodium hydroxide	Bactericide	C_6CI_5OH	Potentially hazardous
Potassium	Mined as the mineral sylvite in carnallite	Flocculant	Potassium chloride KCl	NONE
Sodium bicarbonate	Passils carbon dioxide thru a solution of normal carbonate	Precipitate soluble calcium, pH control	$NaHCO_3$	NONE

Source: Rogers (1963), Robichaux (1975), Land (1974), USDI (1975)

of the barite was found to be greater than 7500 ppm. The concern that the Ba^{+2} ion will be released from barite seems to be unfounded. Barium sulfate has a very low solubility ranging from 0.000246 to 0.000413 gms/100 cc of freshwater. Also, barium sulfate is a non-toxic insoluble salt that is used as an opaque medium in radiography. Investigative results and the physical properties of barium sulfate classify it as a low to non-toxic compound. As long as barium remains in compounds having very low solubilities, it is considered non-toxic. If alteration to soluble forms occurs under certain circumstances in the marine environment, toxicity could be a matter for concern. Presently, the existence or non-existence of such alteration mechanisms is unknown.

The modified lignosulfonates (chromium and ferrochromiums) are prepared by the dichromate oxidation of sulfite pulp lignosulfonate liquor. This reaction firmly chelates the chromium so that it may not be removed from the lignosulfonate complex even by strong ion-exchange resins. Further studies show the chromium ion to be in a trivalent state which may interact with the planar surface of bentonite clays by a base-exchange mechanism. These results would indicate that the trivalent chromium ion added to the drilling mud, in the form of a modified lignosulfonate, is strongly associated with either the lignosulfonate or bentonite clay and as such does not enter into additional reactions. The Gulf Universities Research Consortium (GURC, 1974) reported that results from concentrations in Timbalier Bay in the Gulf of Mexico indicated that toxic metals (barium and chromium) presented no evidence of biological hazard and are below levels promulgated as being harmful to the biota. The values reported for chromium from the Offshore Ecology Investigation data are within the ranges reported for other oceanic waters.

Bioassay studies have shown chrome-lignosulfonate to have a 96-hour TLM in salt water of 12,200 ppm and a 96-hour TL_{50} of 465 ppm. In a study of drilling fluids used in the Canadian Arctic, a concentration gradient of Cr in undiluted mud discharges ranged from 0.3 ppm at the top of the hole to 24.8 ppm at TD. Once on the seafloor, chromelignosulfonate is fairly resistant to biodegradation; however, certain benthic invertebrates are known to concentrate trace amounts of various heavy metals over extended time. The possible role of drilling mud chromium additives in this phenomenon is the subject of ongoing research.

Occasionally, abnormal formation pressures, exceptionally tight formations or other problems require the use of oil-base mud or highly treated drilling muds. Drill cuttings are then separated and cleaned of entrained oil before being discharged overboard, and the drilling muds are retained and shipped to shore and stored in tanks for future use.

Discharge of Produced Formation Waters

Table A-2 presents a representative list of components for three offshore brines for the Louisiana region. Due to the stratification of oilfield brines within a given formation and/or seepage between reservoirs, the chemical and physical properties of the waters may change during the period of oil production.

Under the Federal Water Pollution Control Act of 1972, OCS Order No. 7, (Appendix B), and EPA effluent limitations (1975), the design of formation and other waste water disposal systems will limit the oil content of discharged effluent to a maximum of 72 mg/1 for any one day, and a thirty consecutive day average not to exceed 48 mg/1 (BPCTCA). A maximum of 52 mg/1, for any one day, and a thirty consecutive day average not to exceed 30 mg/1 (BATEA and New Source), assuming more stringent regulations are not in effect. Further assuming that all formation water is discharged (worst case), from 2200 to 2800 barrels of oil per year will be introduced into the marine environment. Over the 25-year anticipated production period, from 55,000 to 70,000 barrels will be introduced.

The Environmental Protection Agency has developed a "Development Document for Interim Final Effluent Limitations Guidelines and New Source Performance Standards for the Oil and Gas Extraction Point Source Category". This document proposes the utilization of "best available" technology to achieve a "no discharge" goal by 1983. This document was published in the Federal Register Vol. 40, No. 179, September 15, 1975. We have not assumed a "no discharge" rate, but if it is in effect then the 2,800 barrels may be substantially lower.

Depending on the physical and chemical properties of the formation waters as well as receiving waters, it is anticipated that the brines will become well mixed in the water column within a

Table A-2 CHEMICAL CONTENT OF REPRESENTATIVE OFFSHORE BRINES 1/

Offshore Louisiana

Component		High Solids		Average Solids		Low Solids	
		mg/1 2/	%	mg/1	%	mg/1	%
Iron	FE	153	0.057	15	0.011	139	0.226
Calcium	Ca	17,000	6.287	4,675	3.294	772	1.254
Magnesium	Mg	2,090	0.773	1,030	0.726	152	0.247
Sodium	Na^+	84,500	31.250	49,120	34.612	22,651	36.800
Bicarbonate	HCO_3	37	0.014	100	0.070	933	1.516
Sulfate	$SO_4^=$	120	0.044	0	0	188	0.305
Chloride	Cl^-	166,500	61.575	86,975	61.287	36,717	59.652
Total Solids		270,400	100%	141,915	100%	61,552	100%

1/ From U. S. Geological Survey, Oil and Gas Supervisor, Gulf of Mexico Area. New Orleans, Louisiana (1975).

2/ mg/1 is equivalent to part per million.

few days of discharge. The impacts resulting from the anoxic formation water are therefore expected to be short-term (actual time dependent upon mixing/dilution rates) and localized.

Disruption of Sea Floor and Resuspension of Sediments During Pipeline Burial

During pipeline burial, large volumes of sediment are disrupted and resuspended for a short time in overlying waters. As the width of the trench varies with the compactness and fluidization point of sediment, we can only estimate the volume of disturbed sediments. If the trench is roughly two meters deep by two to four meters wide, and a parabolic cross-section is assumed, pipeline burial would disturb approximately 1,400 to 3,800 cubic meters per km, some of which would be resuspended. While we have estimated 161 km of marine pipelines, some portions may not be buried; i.e., those sections in water deeper than 60 meters where burial may not be required; sections of the gathering system around groups of platforms may not require burial; and sections in state waters where the Department of the Interior has no jurisdiction and cannot require burial.

Placement of Temporary and Permanent Offshore and Onshore Platforms, Pipelines and Terminal Facilities

It is estimated that a maximum of two onshore terminal/storage facilities may be constructed as a result of this proposed sale. Each facility will require approximately 16 hectares of land. Approximately 20 to 40 offshore platforms will be required as a result of this proposed sale.

Probability of Accidental Oil Spills in the Gulf of Mexico

The most important feature of oil spill statistics as reported by CEQ (1974) is the size of individual spills which range from a fraction of a barrel to over 15,000 barrels. Most spills are at the low end of this range; in 1972, 96% of spills were less than 24 barrels (1,000 gallons) and 85% were less than 2.4 barrels (100 gallons). A few very large spills account for most of the oil spilled (the Torrey Canyon accident of 1967 spilled twice as much oil as was reported spilled in the United States in 1970). In 1970 and 1972, three spills each year accounted for two-thirds of all oil spilled in the United States in those years. Because amounts spilled per incident can vary by a factor of one million, it is meaningless to estimate "average" amounts of oil that might be spilled during development. Data supplied by the Geological Survey for the period of 1964-1976 (only first quarter of 1976) indicate a total of 54 oil spill incidents connected with Federal OCS oil and gas and condensate, and one spill greater than 50 barrels in the California OCS.

The estimated total volume of oil spilled during this period as a result of these incidents is slightly more than 300,000 barrels (12.6 million gallons). A distribution of these 54 Gulf incidents as to type and amount spilled is presented in Figure A-1.

Pipeline Accidents

Since new regulations concerning pipelines went into effect in 1970, the spillage rate has been 0.0017% of total production. At this rate, assuming 11 million barrels of oil per year will be transported by pipeline to onshore and offshore terminals, 187 barrels of oil per year could be spilled as a result of pipeline malfunctions.

Oil and/or Gas Well Blowouts During Drilling

Imminent blowouts may be controlled by increasing mud weight and activating blowout preventers. If these control systems fail, the well will blow out of control, releasing large quantities of oil into the marine environment. If a gas well blows out, escaping gas either burns or disperses into the atmosphere.

Outer continental shelf statistics indicate that one blowout occurs for every 2,860 wells drilled, spilling an average 2,100 barrels of oil.

Oil Spills Resulting From Platform Fires

Combustible hydrocarbon liquids or vapors making contact with arcing electrical or overheated mechanical devices undoubtedly cause most platform fires. More rarely they are ignited by lightning or static electricity. Sometimes platform fires involve the accidental ignition of fuel, solvent or heat exchanger fluids.

If producing wells are damaged to the extent that oil flows freely and ignites, they are usually allowed to burn while remote control operations are underway. In this way, most hydrocarbon liquid expelled by the well burns, reducing the fire hazard during relief operations and lowering ocean pollution levels. If a blowing well is releasing mostly natural gas, ocean pollution is minimal. However, personnel and the platform or drilling structure are imperiled in the event of a fire.

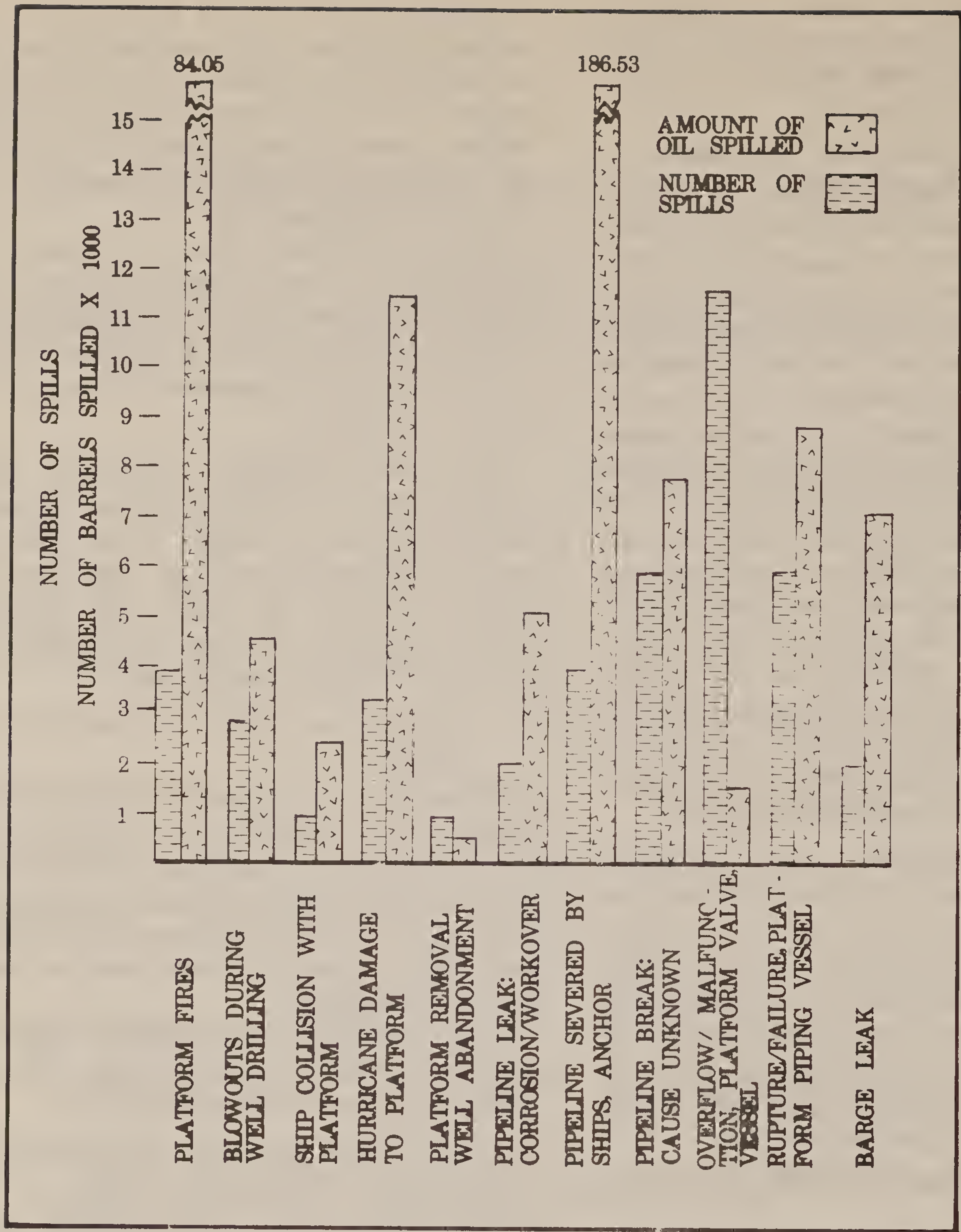


Figure A-1 Oil Spills ≥ 50 bbl. Number and Amount

From 1964 to 1974, many platform fires of varying sizes occurred during OCS production. Most were extinguished without causing serious damage or pollution. Of 84 recorded explosions and fires, four resulted in spills amounting to 84,050 barrels; when compared to the total 10-year production, this results in a spillage rate of 0.0029%. Applying this rate to the anticipated annual production of 11 million barrels, 319 barrels would be spilled per year.

TANKERS ACCIDENTS AND OPERATIONS

Accidents, carelessness or mismanagement releases almost 36.5 million barrels of oil annually into the world's oceans (Charter et al., 1973). Figure A-2 shows the percentage of total outflow from various polluting sources (Porricelli and Keith in press). Table A-3 shows the budget of petroleum hydrocarbons introduced into the oceans as compiled by the National Academy of Sciences (NAS, 1975). Figure A-3 further breaks down data on 269 polluting incidents involving tankers in 1969 and 1970, giving pollution volumes from tank barges and tankers, and from various types of tanker accidents.

About 98% of all the oil spilled by vessels is from incidents involving over 1,000 barrels. Most large tanker spills occur nearshore (within 80 km of land) when the vessel runs aground, rams a fixed structure or collides with another vessel.

During 1973, approximately 1,404 billion tons (10 billion barrels) of oil were transported by tankers; about 1,355 billion tons of crude were similarly transported during 1971 (National Academy of Sciences, 1975). Ten billion barrels will be used in the spillage rate calculations.

From 1969 to 1973, a total of 950,000 long tons of oil were spilled by tankers (Card et al., 1975); average annual spill volume was 190,000 long tons (1.35 million barrels). A ratio of volume transported (10 billion barrels) to volume spilled (1.35 million barrels) results in a spillage rate of 0.013%. The CEQ (1974) report lists a spillage rate for tankers of 0.016%. Tankers will not be used to transport production from offshore to onshore facilities. Pipelines will carry the production from offshore platforms to onshore storage facilities.

The probability of an oil spill and number of spills increases as the amount of production increases (CEQ, 1974).

MINOR SPILLS AND NATURAL SEEPS

Table A-4 lists annual totals of minor spills by number and volume. It should be noted that not all oil slicks are related to offshore drilling, transportation or production.

Most of the oil seeps that have been noted in the Gulf of Mexico are active. Studies were conducted by the U.S. Bureau of Mines around the Gulf of Mexico to determine (1) whether previously reported seeps are still active; (2) the characteristics of the seeping hydrocarbons; and (3) the amount of bitumen (asphalt found in a natural state) contained in the drainage leaving the seeps and entering the Gulf of Mexico.

When total minor spills in barrels per month are plotted against time, a smooth curve representing a constant 2.57% decline is noted. During the period 1970-1973, total oil and condensate production varied by less than 13%, whereas minor oil spill volume decreased almost 60%.

From 1970 to 1974, the spillage rate was 0.000274%. Projecting this rate to the present proposal's estimated maximum production of 11 million barrels per year, maximum minor spill level is 30 barrels per year. If the downward trend of minor spill volumes continues, the figure could be somewhat smaller. By definition, the maximum size of a single minor spill is less than 50 barrels.

ACCIDENTAL SPILLS FROM OVERFLOW, MALFUNCTION, RUPTURE OR FAILURE OF PLATFORM PIPING VALVES

These are minor spills in which 50 barrels or more were lost before the condition was corrected. Accident records for the Gulf of Mexico indicate 12 such spills through 1973. Total spillage was 1,558 barrels, or an average of 130 barrels per spill.

Assuming these conditions, the rate of 1,558 barrels spilled to 2.9 billion barrels produced is 0.000054%. At a maximum production of 11 million barrels per year, the spillage in the proposed lease area would be six barrels per year.

In summary, an estimated 3,342 barrels of oil will be spilled annually (Table A-5) in the northern Gulf of Mexico. This does not include the 2,100 barrels spilled from the projected blowout of one well sometime during the life of production.

Probability of Spills Due to Natural Phenomena

The preceding section dealt with estimates on the volume of oil that may be spilled annually as

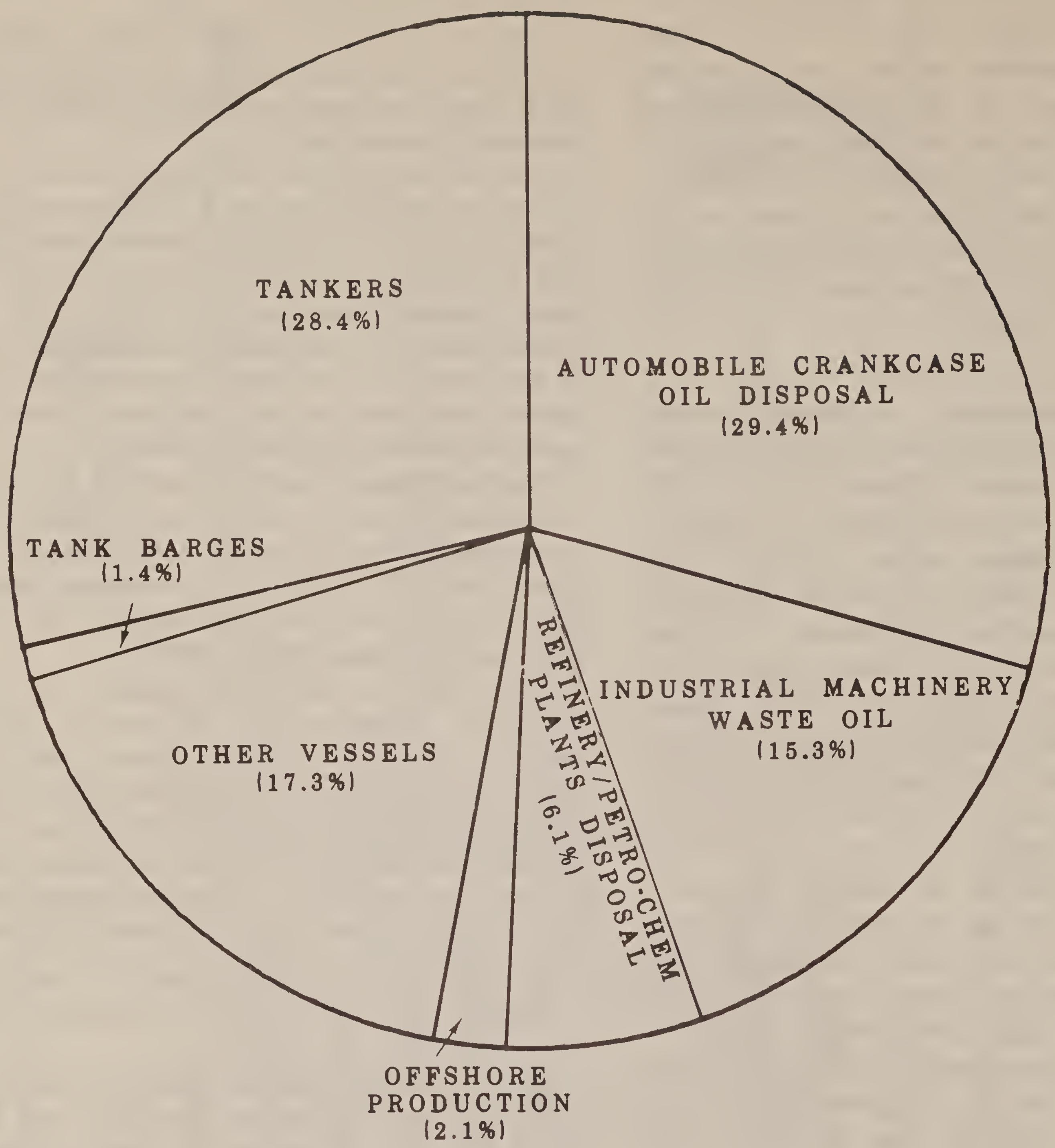


Figure A-2 Sources of Oil Pollution to the Oceans.

Source: Poricelli and Keith

Table A-3 Budget of Petroleum Hydrocarbons Introduced into the Oceans

Source	Input Rate (mta)[a] Best Estimate	Probable Range	Reference
Natural seeps	0.6	0.2-1.0	Wilson et al. (1973)
Offshore production	0.08	0.08-0.15	Wilson et al. (1973)
Transportation			
LOT tankers	0.31	0.15-0.4	Results of workshop panel deliberations
Non-LOT tankers	0.77	0.65-1.0	
Dry docking	0.25	0.2-0.3	
Terminal operations	0.003	0.0015-0.005	
Bilges bunkering	0.5	0.4-0.7	
Tanker accidents	0.2	0.12-0.25	
Nontanker accidents	0.1	0.02-0.15	
Coastal refineries	0.2	0.2-0.3	Brummage (1973a)
Atmosphere	0.6	0.4-0.8	Feuerstein (1973)
Coastal municipal wastes	0.3	-	Storrs (1973)
Coastal, Nonrefining, industrial wastes	0.3	-	Storrs (1973)
Urban runoff	0.3	0.1-0.5	Storrs(1973)Hallhagen(1973)
River runoff	1.6	-	Storrs(1973)Hallhagen(1973)
TOTAL	6.113		

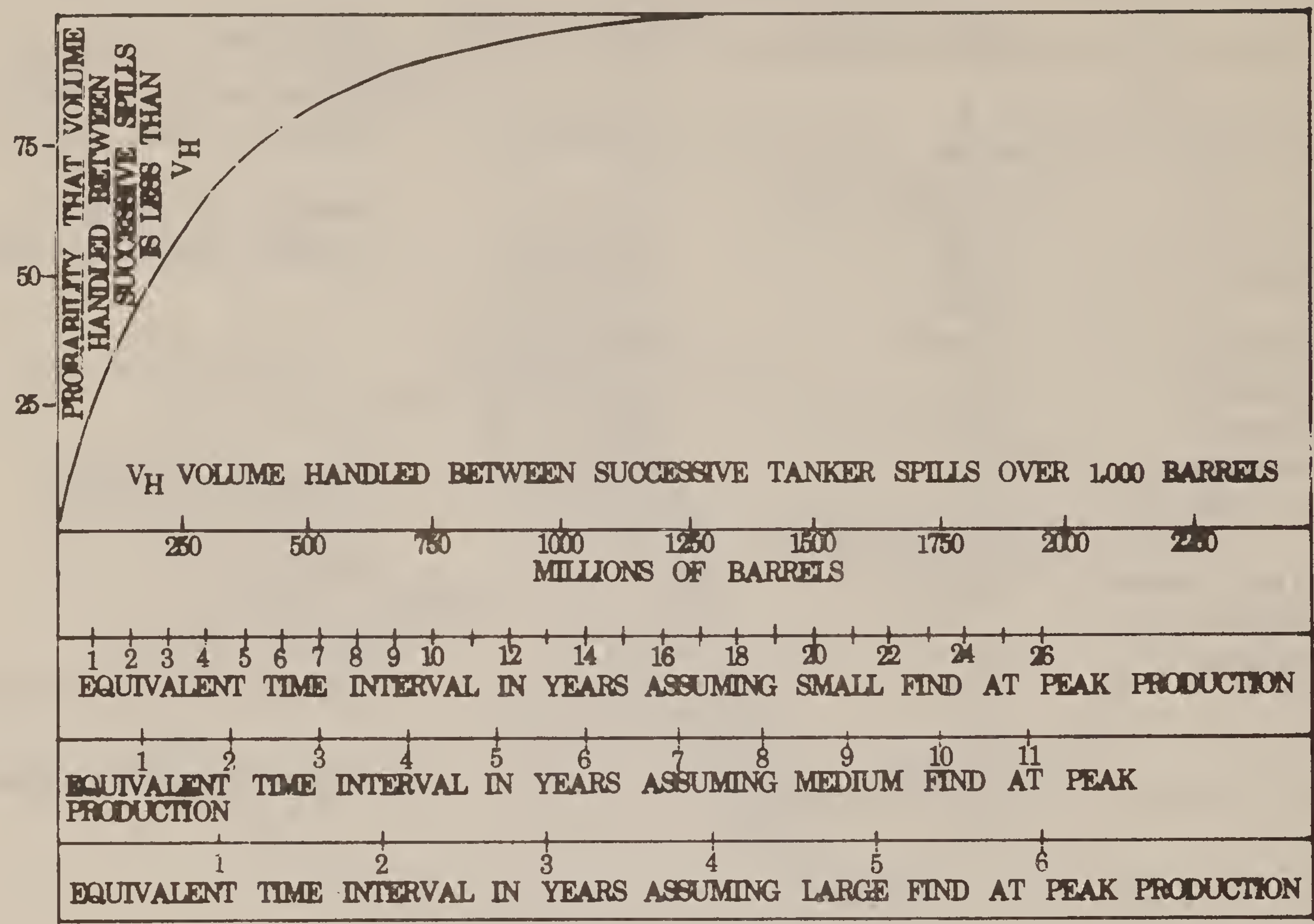


Figure A-3 Cumulative volume of oil handled between tanker spills larger than 1,000 barrels.

Source: MIT 1974

Table A-4 Minor Oil Spills

Year	Total Number Reported	Source by Number: Drilling	Source by Number: Prod. & Trans.	Total Volume (bbl)	No. Oil Slicks Sighted; not Identi. by Source
1970	1,200	4	1,196	2,597	745
1971	1,250	13	1,237	2,414	878
1972	1,158	13	1,145	1,812	606
1973	1,392	10	1,382	1,857	958
1974*	213	3	210	165	143

* First Quarter Only

Source: USGS, 1974

TABLE A-5

Anticipated Annual Oil Spillage During Peak Production Results from the Proposed Sale

Location	Source	Maximum Annual Spillage (bbls)
Gulf of Mexico	Pipeline accidents	187
	Formation water*	2800
	Spills from platform fires	319
	Overflow, malfunction, or rupture	6
	Minor spills (less than 50 bbls--all sources)	30
TOTAL		3,342

*Assuming all formation water is discharged.

a result of human error and equipment failure. This section is devoted to oil spill probability estimates due to natural phenomena in the proposed sale area. The discussion, with minor changes, is taken from the CEQ (1974) report which estimated the likelihood of natural phenomena damaging or destroying an offshore structure. CEQ used an analytical approach considering design criteria, safety specifications of the structure and likelihood of a particular event.

Major offshore structures are designed to withstand an environmental stress as specified by the future owner or operator. Typically, forces associated with the 100-year storm have been the specified stress. However, there is always a chance that these forces will be exceeded, resulting in an oil spill. For example: Over a 30-year field life, the probability of at least one storm with forces greater than the 100-year storm is 26%; with forces greater than the 200-year storm, there is a 14% probability.

Based on several assumptions, including: the probability that a natural event will occur is adequately described by recurrence relations given in previous sections of their report; structural designers can develop designs that will withstand the forces of specific natural events (e.g., earthquakes with magnitudes less than 7.2), and a specific natural event will occur in the vicinity of an oil field, exposing the structures to the full forces associated with the event; the CEQ calculated the number of times oil spills can occur due to natural phenomena.

The field life (production period) of an oil reservoir depends on reservoir volume, depth of water at the site, amortization costs, and time required to develop the field. Based on past industry practice, field life for the northern Gulf of Mexico reservoirs will probably be between 20 and 40 years. Calculations were therefore made for 20-year, 30-year, and 40-year field life.

Estimate of the Likelihood of Platform Collapse and Well Blowout From Storms

Unprotected wells can blow out if the platform collapses from excessive storm forces.

The probability of a storm exceeding the design has been calculated for design specifications of both 100- and 200-year storms with safety factors of 1.5 and 2.0. The analysis further assumed the platform would experience the full effects of a storm exceeding the design spectrum. If a platform collapses, conductor pipes will shear. However, the positive open control lines to the subsurface valve will also shear thus closing the valve and preventing loss of oil. Valves are not 100% reliable; however, recent tests show a 0.96 to 0.97 reliability. CEQ used 0.96 for their calculations. Industry is sponsoring research to identify the failure modes of subsurface valves to improve design and thus increase reliability. To show how improved reliability would reduce failure rates, the CEQ also selected a valve reliability of 0.99 for their calculations.

The value of improving reliability is illustrated in the following example: A platform in the proposed sale area is designed to withstand the 100-year storm and has a margin of safety of 1.5. If field life is 30 years, then the possibility of exceeding the platform design specifications during the life of the field is 0.14 (or 1 chance in 7). If subsurface valving is installed, the chance for a blowout is 0.006 (1 chance in 167) for a reliability of 0.96, and 0.0014 (1 chance in 700) for a reliability of 0.99.

Table A-6 illustrates two important points. First, likelihood of platform collapse increases linearly as the age of the field increases and decreases linearly as the design storm criteria is increased. For example, a platform designed for the 100-year storm in a 20-year field will have the same likelihood of failure (0.09) as a platform designed for the 200-year storm in a 40-year field.

Estimates of the Likelihood of Oil Spillage From Storage Systems

The three types of storage facilities are onshore, floating, and underwater facilities. Government regulations now require that dikes enclose onshore storage tanks so that if the tank fails, the released oil will not escape from the area. CEQ maintains, therefore, that the chance of oil spills due to natural phenomena is zero, provided dikes are not damaged. Damage to dikes is very dependent on quality of the soil foundation. It is extremely important that a thorough geologic investigation of the proposed site be made to confirm that the soil properties are satisfactory.

Likelihood of failure has been calculated for floating and underwater storage (Table A-7). Storms are the only natural phenomena affecting floating storage placed in deep water. The same linear relation exists between field life and more

TABLE A-6

Estimate of Platform Collapse and Well Blowout
(Safety Valve Reliability - 0.96 and 0.99)

Field life in years

Severe storm design standard				
100-yr storm				
Margin of safety - 1.5	.09/.0036/.0009*	.14/.0056/.0014	.19/.0076/.0019	Average number of times severe storms will cause well blowout
Margin of safety - 2.0	.04/.0016/.0004	.07/.0028/.0007	.08/.0032/.0008	
200-yr storm				
Margin of safety - 1.5	.05/.002/.0005	.07/.0028/.0007	.09/.0036/.0009	
Margin of safety - 2.0	.02/.0008/.0002	.03/.0012/.0003	.04/.0016/.0004	
Combined Severe Storm and Tsunami				
100-yr storm	.001/.00004/.00001	.0015/.00006/.000015	.002/.00008/.00002	
200-yr storm	.0005/.00002/.000005	.0007/.000028/.000007	.001/.00004/.00001	

*Platform Collapse/Well Blowout = 0.96/Well Blowout R = 0.99
Reliability = 0.96/well blowout
R = 0.99

Source: CEQ 1974

TABLE A-7

Average Number of Times that a Storage System will be Damaged as a Result of Natural Phenomena

	Field Life in Years 20	30	40	Remarks
Ashore	0.0	0.9	0.0	Dikes have 100% reliability against damaging oil spill
Afloat				
100-yr storm				
Margin of safety - 1.5	.095	.14	.19	Average number of times severe storms will cause parting of floating storage moor
Margin of safety - 2.0	.044	.066	.088	
200-yr storm				
Margin of safety - 1.5	.047	.070	.093	
Margin of safety - 2.0	.022	.033	.044	
Underwater				
100-yr storm				
Margin of safety - 1.5	.095	.14	.19	Average number of times severs storms will damage or destroy underwater tanks
Margin of safety - 2.0	.044	.066	.088	

Source: CEQ 1974

stringent design criteria. That is, if field life is doubled, then the recurrence interval for the design storm should be doubled, to maintain the same probability.

These estimates are based on the likelihood that a floating storage tank will break its moor and go adrift. If capsizing or grounding can be avoided, and if service craft can regain control of the drifting tanks, oil spillage will be averted. A spar-type floating storage will minimize capsizing. This system uses long vertical cylinders which are very stable and experience very little motion even in heavy seas. However, since it will usually extend several hundred feet below the surface, it must be moored in deep water.

Combining probabilities for all natural phenomena affecting floating and underwater storage in the Gulf of Mexico, underwater storage is more susceptible to damage by natural phenomena than floating storage.

To summarize, onshore storage is the safest form of storage in the Gulf of Mexico from the aspect of natural phenomena. When it is not feasible, floating storage is safer than underwater storage.

Estimates of the Likelihood of Natural Phenomena Damage to Transportation Systems

Properly designed, constructed and emplaced pipelines are relatively insensitive to all natural phenomena except ground faulting and slumping along the pipeline route. The possibility of soil stability loss cannot be assessed until after a thorough geologic analysis of the selected route and after selection of a valve location program. These steps are taken during the late stages of the exploration program and follow the decision that the reservoir warrants development.

Summary and Conclusions

Table A-8 summarizes the effects of each of the natural elements, the volume of oil at risk, and the caveats regarding certain evaluations. Severe storms do not present a serious oil spill threat to any of the elements of the system. Threat to floating and underwater storage is "moderate" due to the volume of oil at risk.

The stability of soil beds including faulting also threatens pipelines. Careful route planning and an adequate valve program may relieve some risk.

Several typical oil production systems have been assembled and estimates of the value from the aspect of minimizing oil spillage are made for four typical oil production systems (Table A-9). Pipeline and onshore storage is considered best for this proposed sale area. Floating moors rather than fixed berths for tankers represent a lesser risk of massive oil spillage (CEQ, 1974).

Oil Spill Trajectories in the Gulf of Mexico

Oil spills on the ocean surface are usually described in terms of spreading, drifting, and weathering. However, a combination of many factors controls oil movement and composition. A partial list of these factors includes: original composition, age, solubility, total amount introduced, concentration, dilution, evaporation, photo oxidation, absorption on suspended particulates, microbial degradation, spill treatment, water salinity, temperature, waves, winds, currents, season, geographical location, and climate.

Results of Oil Spills in the Gulf of Mexico

Fates and Effects of Oil in the Marine Environment

The following discussion was taken, with few changes, from the report of the workshop on "Inputs, Fates, and the Effects of Petroleum in the Marine Environment", *Petroleum in the Marine Environment,* National Academy of Sciences (1975).

This section represents an attempt to discuss in summary form the fate of an oil spill on the sea, from its initial fluid, unmodified condition through its final residual forms. The resulting slick is dispersed by physical forces and chemically modified by oxidative and biological processes. As the spill ages, the relative impact of the various dispersive and degradative processes shifts from the rapid physical effects to slower chemical and biological modifications. The rate of dispersion of a spill is primarily a function of air-sea dynamics, chemical and physical properties of the oil, and the magnitude of the spill. In spite of the seeming complexity of this problem, it is possible to identify stages in the lifetime of a spill and to assign priorities to the processes acting to modify it. An understanding of anticipated events is essential for designing and deploying oil recovery equipment, interpreting aerial spill surveillance data, and tracing a petroleum residue to its source in order to determine the fate of oil on the sea.

These processes can be divided into three stages. Initially, the fluid spill spreads rapidly

TABLE A-8 EVALUATION OF VARIOUS COMBINATIONS OF ELEMENTS BASED ON LOWEST PROBABILITY OF OIL SPILLS

	SYSTEM A	SYSTEM B	SYSTEM C	SYSTEM D
	WELLHEAD PIPELINE STORAGE ASHORE TANKER (FIXED BERTH)	WELLHEAD PIPELINE STORAGE ASHORE TANKER (SPM)	WELLHEAD UNDERWATER STORAGE TANKER (SPM)	WELLHEAD FLOATING STORAGE TANKER (SPM)
GULF OF MEXICO	POOR	BEST	POOR	GOOD

Source: CEQ 1974

TABLE A-9 SUMMARY OF THE EFFECT OF NATURAL PHENOMENA ON VARIOUS ELEMENTS OF THE OIL PRODUCTION SYSTEM.

Natural Phenomena

ELEMENT		SEVERE STORM	VOLUME OF OIL AT RISK PER EVENT
PLATFORM		SLIGHT (note 1)	500 to 1500 BBLS/Well/Day
PIPELINE		NONE	10,000 BBLS or More
STORAGE	ASHORE	SLIGHT (note 5)	Up to 1,000,000 BBLS or Greater (note 7)
	AFLOAT	MODERATE	200,000 TO 1,000,000 BBLS
	UNDERWATER	MODERATE	100,000 BBLS or Greater
UNDERWAY		SLIGHT (note 10)	500,000 to 2,000,000 BBLS
MOORED-SPM		SLIGHT (note 11)	
FIXED BERTH		SLIGHT	

NOTES:

1. Storm forces are comparable to those in the North Sea.
2. Provided earthquake resistant design features are used.
3. Provided careful soil analysis program is followed.
4. It may be possible to reduce threat by line routing over less susceptible areas.
5. Provided tanks are sited away from flood prone areas.
6. Provided free surface effect is reduced.
7. Dikes give protection against damaging oil spill.
8. Assumes control can be regained before floating storage grounds or capsizes.
9. Provided floating storage is moored in deep water.
10. Assumes regular inspections and prudent seamanship.
11. Assumes ship control is regained before grounding.

SOURCE: CEQ 1974

under the influence of gravitational and surface chemical effects. The polar, surface active constituents (containing nitrogen, oxygen, and sulfur) are highly influential in spreading the spill into extremely thin layers that approach non-molecular dimensions at the outer edges of the slick. In addition, the extent and rate of slick growth is determined by wind, waves, and current and by the density and viscosity of the spilled petroleum. The rate of most dispersive processes is greatly enhanced by spreading the oil into thin layers. Thus, surface-to-volume ratio of the spill increases and a greater exposure to air, sea, and sunlight results. In this early stage, evaporation is the predominant dispersal process, and its rate increases with winds and the further spreading of the spill. In rough seas with breaking water and wave-induced surface contractions, oil is emulsified into the ocean. The entrained oil may also be sedimented by adsorption onto nonbuoyant particulate matter. Another process occurring in rough weather is the transport of oil into the atmosphere by ejection of oil-coated drops from sea spray and bursting bubbles. Fallout of this oily mist usually returns to the sea downwind and usually is outside of the initial spill. If the spill had occurred in coastal waters, it may fall out on nearby land.

It is difficult to determine whether the dissolution rate will increase or decrease with time. Dissolution is slow for most of the compounds found in petroleum: The more soluble compounds, spread into thin layers initially, will dissolve in the underlying water. Organic acids will be solubilized by reaction with the relatively alkaline seawater, and photocatalyzed oxidation may produce species more volatile or soluble than the parent compound. Processes of this kind achieve a more important dispersant role at a later stage in the life of the spill after the most volatile compounds have been evaporated. In this mesostage, photochemical and biological degradation assumes a more dominant role. The expansion of the slick by spreading has essentially ceased. The rate of dispersion of the thin external portions of the spill is balanced by the rate of spread from thicker central portions. In addition, for crude and residual fuels, loss of light ends creates a more viscous substance that does not flow readily along the air-water interface.

Thus, the density and viscosity of the residue increase, and eventually the third, most refractory stage is reached. The size of the resulting tarry residue is large when thick layers have weathered under relatively mild meteorological conditions. Smaller fragments are produced by waves and breaking water. Further degradation, weathering and interaction with the environment is extremely slow since the surface-to-volume ratio of unspread tar is small, and most dispersive reactions occur at interfaces. More importantly, since the petroleum residue is nonfluid, additional spreading ceases and the internal contents become encapsulated and isolated from effective interaction with dispersive and degradative processes. Microbial degradation becomes important as populations of hydrocarbon-adapted bacteria develop.

Although distillate fuels would undergo many of the dispersive processes listed above, there would be little tendency to form tar balls. However, because most of the petroleum spilled on the sea surface contains non-volatile, high-molecular-weight components, tar formation is likely. These sources include accidental spills, bilge pumping, and tank-cleaning operations, as well as input from land-based sources and undersea seeps.

It is important to note that although the initial dispersion of a slick is fairly well understood, the longer term process (except possibly for bacterial degradation of normal paraffins) has not been studied under field conditions. Much of what we have presented is thus an extra polation of processes studied mainly in the laboratory and should be verified by field studies.

At present, field data are rather sparse, making it difficult to generalize sufficiently to predict the probable levels of petroleum residues in a given area where their effects might be important (e.g., an estuary). In addition, the distinction has not always been made between hydrocarbon materials resulting from natural sources such as biosynthesis or crude oil seeps. Time-series data for petroleum residues are available only for a few locations such as Florida (Dennis, 1959), Bermuda (Butler et al., 1973), and West Falmouth (Blumer et al., 1970b), (Blumer and Sass, 1972), and even in these locations, surveys cover only a few years. In the following, reservoirs of petroleum (principally hydrocarbon) residues are classed as atmosphere, sea surface microlayer, pelagic tar, water column, and sediments.

Few of the available measurements of atmospheric hydrocarbon concentration are good

measures of the reservoir of petroleum hydrocarbons in the atmosphere over the sea. Furthermore, most of the atmospheric hydrocarbons are low-molecular-weight (methane to C_6) and would not enter other parts of the marine environment without first being oxidized or possibly adsorbed on particulate matter.

Although hydrocarbons themselves are not surface active, they tend to be accumulated at the sea surface by naturally occurring surfactants.

One important consideration is that oil slicks or surface films in nonslick areas may act as a differential accumulation center for tract materials (Filby and Shah, 1971, Guinn and Bellance, 1970) such as metal ions, vitamins, amino acids and such lipophilic pollutants as DDT residues and PCB (Duce et al., 1972, Guinn and Wade, 1972). Whatever ecological effects these materials have on the life near and at the sea surface, they may be substantially altered by the presence of oil slicks; and as a result, the ecology of the sea surface may be changed with possible consequent impacts on other pelagic life (Feldman, 1970).

In the last few years a number of quantitative measurements of the weight of tar lumps collected by neuston nets have been published.

There is a suggestively strong correlation between the observation of high levels of pelagic tar and known tanker routes of high traffic.

Distinguishing tar lumps formed from natural crude oil seeps and those resulting from tanker operations is clearly important, but criteria for such distinctions are still being developed. We have already mentioned the presence of C_{30}—C_{40} paraffinic waxes as being indicative of crude oil sludge (hence tanker) origin, and the presence of relatively large amounts of iron as being strong evidence for person-caused sources.

If the input of petroleum to the world oceans from natural seeps is about 10% of the total, one might expect to find some tar lumps of natural origin in areas where there are substantial seeps. At present, the surveys of tar quantities are too scattered to permit any specific correlation, but multiparameter analysis of oil from various known seeps and from tar lumps collected in nearby regions might permit some significant correlations to be made. There is reason to believe, however, that since natural seeps contribute crude oil at a slow, more or less steady rate (Allen et al., 1970), the resulting oil slick would be expected to be quite thin and the tar lumps (if any) formed from it would be expected to be of different character from those formed by tanker residues. For example, Ludwig and Carter (1961) reported gas bubbles in tar formed from natural seeps. As mentioned above, aggregation of small lumps does not seem to be a significant mode of tar-lump formation, and thus the large pelagic tar lumps collected by most workers would seem to be most likely the result of tanker operations and possible bilge pumping.

Modification of tanker practice to emulsify wastes before dumping would tend to decrease the amount of pelagic tar but increase the amounts in the subsurface water column. Whether the degradation rate to CO_2 would be enhanced by such a change, or whether the sublethal effects on the ocean ecosystem would be increased, are both open to question at present.

In addition to tar lumps, petroleum residues also enter the dissolved and particulate hydrocarbon pool in the deeper oceans. Conflicting results and controversy about methods makes any quantitative estimate very uncertain at this time. The surface values in the open ocean appear to be less than 10 ug/liter, and subsurface values are much lower.

Biogenic hydrocarbon input may be comparable: approximately three million tons per year (Revelle et al., 1971) to 10 million tons per year (Button, 1971). At the low concentrations found, distinction between biogenic and petroleum hydrocarbons is still beyond the state of the art. However, indirect inference from correlations with phytoplankton may give some information (Zsolnay, 1973). Of course, a great deal of further field and analytical work would be required to verify this.

Total worldwide hydrocarbon concentration (including biogenic compounds) in surface sediment samples determined by a variety of techniques, cover the 0.1-12 ppt range (usually <1 ppt) in highly polluted coastal areas, less than 100 ppm (usually <70 ppm) in unpolluted coastal areas and deep marginal seas or basins, and 1-4 ppm (including about 90% biogenic) in deep sea areas.

The effects of oil spills may be acute or chronic in nature. Acute effects on the biota are those that result from a single infusion of oil into the marine environment from an accidental spill. Mortalities due to petroleum and its by-products may occur almost simultaneously with, or at any time

after, the appearance of the oil in the environment. The effects may be due to chemical or physical characteristics of the petroleum. One such effect is the smothering or asphyxiation of organisms by a coating of oil.

Some spills occur within confined marine areas, such as bays or estuaries, where the concentration may remain high for extended periods causing the biological impacts to be greater than if the oil were released where rapid dispersion could take place. Such releases are generally large compared with chronic low-level additions, and furthermore, they commonly occur in coastal waters where man makes maximum use of marine resources.

The public is concerned when seabirds at nearby beaches and nesting areas are oiled and when shellfish are killed or tainted such that they are unpalatable. When beaches are polluted with oil, public use decreases.

Chronic effects are those that occur from the release of crude oil or its derivatives either continuously or sufficiently often that the biota does not have time to recover between doses. Other activities associated with the petroleum and other industries may have a long-term or chronic effect on aquatic organisms. For example, dredging and filling of marshes can modify organism habitats and either kill or have sublethal effects on individual organisms. The sublethal modifications may affect the characteristics of the populations of each species, changing the rates of birth, death, and dispersal, as well as the age structure and spatial pattern. Also, changes in the ecological communities may occur in the affected area.

There are various levels of biological effects of oil. At various places in the marine environment and at various times these will be accorded different priorities in the evaluation of the impact. These effects include the possibility of:

Human hazard through eating contaminated seafood;
Decrease of fisheries resources or damage to wildlife such as seabirds and marine mammals;
Decrease of aesthetic values due to unsightly slicks or oiled beaches;
Modification of marine ecosystem by elimination of species with an initial decrease in diversity and productivity;
Modification of habitats, delaying or preventing recolonization.

When an oil spill occurs, many factors determine whether that spill will cause heavy, long-lasting biological damage, comparatively little or no damage, or some intermediate degree of damage. An example of the variability that exists among the effects of oil spills on the marine biota is outlined by Mitchell et al. (1970) in his description of the widely different effects resulting from the Tampico Maru and the Santa Barbara oil spills. Several factors apparently contributing to the difference in those effects are compared. Straughan (1972) also identifies various factors that influence the extent of biological damage from an oil spill.

If the spill occurs in a small, confined area so that the oil is unable to escape, damage will be greater, almost without exception, for a given volume and type of oil spilled than if that same volume were released in a relatively open area. At the Tampico Maru site, 60,000 barrels of diesel fuel were spilled in a small cove, whereas at Santa Barbara 75,000 barrels of crude oil were spilled in an open ocean channel. The Tampico Maru spill had greater, more persistent damage than the Santa Barbara spill, most likely because it occurred in a confined area. Thus, where the spill occurs, as well as the volume of oil spilled, are both important factors.

The Tampico Maru spill involved No. 2 diesel fuel and the Santa Barbara spill involved crude oil (Mitchell et al., 1970); because No. 2 diesel fuel oil contains more aromatic compounds, it is more toxic. The type of oil spilled may be the most important factor, as evidenced by the difference in severity accompanying the spill by the barge Florida at West Falmouth, Massachusetts (Blumer et al., 1971a), which was carrying No. 2 diesel fuel oil, and the Torrey Canyon spill, which involved Kuwait crude oil (Smith, 1968). A definitive study of the difference in toxicity among various oils is reported by Ottway (1970), who showed that the susceptibility of a snail, *Littorina littorea*, varied markedly according to which of 20 test oils it was exposed.

Currents, wave action, and coastal formation all combine to influence the dosage of a given spill. Currents and wave action, especially in an open body of water such as a large bay, channel, or the open ocean, dilute the spilled oil, thereby reducing the toxicity of the spilled oil (Straughan, 1972).

Normally, storms will increase wave action and thereby reduce the toxic properties of the spilled oil by dilution. On occasion, however, wave action may intensify the problems, as apparently occurred at the West Falmouth spill. Soon after this spill, the surf drove the oil ashore into the sedi-

ments and the surrounding marshland. The oiled marshland and sediments then became a reservoir of oil for many months (Blumer et al., 1971a).

The amount of turbidity in the water is significant in determining the fate of the spilled oil. If the water contains suspended sediments or solids, much of the oil will sink. At Santa Barbara (Kolpack, 1971) the spill occurred during a period of heavy storms that caused considerable freshwater runoff. Sediments that were introduced by the flood waters into the nearby coastal waters provided an adsorptive surface for the spilled oil. Upon wetting the sediment surfaces, the oil flocculated the particles and subsequently sank. Such sedimentation is advantageous if the intertidal life is abundant, but it may be detrimental to benthic life (Blumer et al., 1971a).

The season of the year in relation to the life cycle of a given organism can frequently be the factor determining whether the effect of a spill is severe or relatively light (Straughan, 1972). For example, if a spill occurs during the winter in an area where seabirds are nesting, bird mortality may be in the thousands; at some other time of the year, the mortality would be much lower. Similarly, if a spill occurs in an estuary when fish fry are going into the Gulf, a much higher kill is likely. Crab larva, which float near the surface of the water in their zoea form, will probably be killed if a spill occurs during this stage of their life cycle (Mironov, 1969). Newly set oyster spats are also exceedingly vulnerable. However, such damage would not occur at other times of the year when these organisms are at a different stage of development.

Straughan (1972) reports that at Santa Barbara the barnacle *Balanus glandula* was not as easily smothered by oil as the barnacle *Chthamalus fissus. Balanus glandula* is larger in size and can survive a thicker layer of oil encrusted on the shoreline. Also, it has a calcareous base plate, whereas the smaller barnacles do not; because the plate prevented direct exposure to the substrate, it resettled earlier. According to Straughan's observations, the type of biota is important in assessing damage.

At present, mechanical methods are the least damaging methods of cleaning up oil spills (Straughan, 1972, Gatteleir et al., 1973). Such methods involve the use of booms and skimmers or absorbents.

Sinking agents, such as sand and stearated chalk, are another method of cleanup. The precise fate of sunken oil would indicate that further experiments are needed before this method can be recommended. Sinking may extend the period that the benthic fauna may be affected (Struzewski and Dewling, 1969).

The use of dispersants is another controversial method. According to Cowell (1971) and Smith (1968), most of the damage that occurred at the Torrey Canyon spill was caused, not by the use of dispersants, but by their misuse. Specifically the dispersants were applied undiluted to oil after it had come ashore. Moreover, Beynon (1970) and Canevari (1971) point out that since the Torrey Canyon incident, dispersants have been developed that are far less toxic and, if properly used, pose a minimum threat to or burden on the marine environment.

Those opposed to the use of dispersants claim that dispersing the oil into the water column renders the oil easier for marine organisms to assimilate (Blumer, 1969a, b; Murphy and McCarthy, 1970). Dewling (1971) pointed out that the use of dispersants, especially in rivers and estuaries, imposes an added burden on the assimilative capacity of the river or estuarine system to biodegrade the oil/dispersant mixture.

Straughan (1972) points out that in certain circumstances such as the protection of an endangered species of birds, the use of low-toxicity dispersants may override all other considerations. Beynon (1971) stresses the advantage of using dispersants on oil spills to prevent the oil from washing ashore and killing intertidal organisms because of its toxicity or by smothering.

Because opinion is polarized concerning the use of dispersant, research under field conditions is needed to establish the conditions and circumstances under which dispersants can be used effectively.

In addition to variables in effects caused by physical factors another set of variable effects is caused by the type of substrates with which the oil comes in contact.

Oil trapped in tide pools on falling tides can saturate small volumes of water with dissolved organics for periods ranging to several hours. Toxicities might become intensified as a result. Oil deposits on attached epifauna and flora can result in layers several centimeters thick. Usually such material is at least partially removed by the rising

tide. Toxic effects may appear where stranded oil contacts tissues directly, such as on plant life (Holmes, 1969). Smothering may develop when tarry residues build up (Straughan, 1971).

Oil stranded on beached or falling tides tend to percolate into the sediments, which provides an opportunity for intimate contact with the infauna. Sedimentary transport processes can move the oily particles away from the region of initial contact, thus extending them along the shore as well as to subtidal waters.

Any oil absorbed by sediment grains may be exposed when the wave scour removes the overburden. Logically, oil dispersed as fine films on small particles should be ideally suited for microbial attack, but rapid degradation requires abundant oxygen, and sediments may easily become anerobic, thus delaying degradation by microorganisms. Oil trapped in sandy English beaches persisted for several months. (Smith, 1968) and was not released until later by various agents.

Oil stranded in marshland also enters sediments and can penetrate at least 70 cm (Burns and Teal, 1971). Oil residues were detected in organisms from various levels of the food web approximately a year after the West Falmouth spill in the Wild Harbor River Marsh (Burns and Teal, 1971). Also, substantial quantities of residues were recovered about 1½ years after the West Falmouth spill.

Studies of the estuarine and marshy waters affected by the West Falmouth spill indicate that oil spilled in this type of habitat could have far-reaching effects if spawning and nursery functions became affected. Blumer et al., (1970a) recorded an unexpected rise in sedimentary oil content of the estuarine muds in Wild Harbor many months after the initial spill. This rise was attributed to a release of oily material from the nearby marshland. The new infusion caused additional adverse effects among the infauna (Sanders et al., 1972). The system was thus able to "store" oil for later release.

Usually, oil floats on the sea surface, but several mechanisms can sink it, thus exposing subtidal communities. For oil to sink, sedimentary particles must contact the slick, forming a denser aggregate of oil-coated particulates that can settle. Such processes may occur in surf (North et al., 1964) from stranding in the intertidal area (Blumer et al., 1970a), or from contact with turbid runoff (Kolpack, 1971).

Oil may be introduced with brines that are associated with its production. Separation of petroleum from aqueous phases is never complete. When the brines are discharged into coastal water, they may carry with them from 10 to 50 ppm oil and even higher quantities of other noxious substances. The soluble fractions of petroleum probably are the most harmful to marine organisms. The characteristics of estuaries may combine with the chronic introduction of oil wastes from brines to intensify biological effects.

In addition, the slow dispersal of oil in some estuaries can increase adsorption onto suspended particulate matter. When these suspended particulates are incorporated in the sediments, the exposure of benthic organisms to oil is increased. The high biological productivity of estuaries ensures the exposure of many organisms to the wastes, particularly in the sensitive stages of their life history. Synergistic interactions between extremes of temperature and salinity and oil may aggravate deleterious effects. Therefore, because they combine biological productivity with the most severe exposure to wastes, estuaries are most vulnerable to the serious effects of chronic oil pollution.

Biological effects from large oil spills vary so widely that it is difficult to generalize on any specific topic such as productivity. Damage to plants can occur during acute phases of spills. Such effects have been recorded for phytoplankton (Mironov, 1970), attached algae (North et al., 1964), and flowering plants (Holmes, 1969). Documentation that shows plant life surviving virtually unharmed after oil spills is also available (Smith, 1968, Straughan, 1972). Plants are relatively resistant to toxicity from oil and require substantial exposure under natural conditions before significant damage results.

Productivity may be limited by the availability of nutrients or by activities of herbivores. Nutrient availability is probably not affected by oil, but destruction of herbivores can occur. Many macroinvertebrate grazers require months or years to develop. If grazing populations are seriously reduced by catastrophe, algal blooms of rapidly growing species can appear.

Presumably similar effects may occur in a planktonic situation. The time scale involved in phytoplankton blooms due to similar causes is much shorter than for kelp beds and other attached algae.0

Oil at very low concentrations, which causes no direct mortality, may have some adverse effects on populations and, in turn, on natural communities.

Because organisms have different tolerances to oil and oil products, changes in relative abundances can occur. Within a trophic level, resistant species may flourish when populations of sensitive species decline and make available previously limited resources. Between trophic levels, a reduction in the number of grazers can lead to drastic habitat changes with the establishment of a canopy of macroalgae (North et al., 1969) and the shading out of the diatom flora on the substrate. Subtle disturbances to populations and communities could arise from or because of interference with chemical communications involved in feeding and mating.

Any possible effect on fishery productivity is of prime concern in coastal areas where there are chronic inputs of petroleum hydrocarbons. Although most evidence indicates that chronic pollution by petroleum has not seriously affected fishery productivity along large sections of the coasts of Louisiana and the North Sea, the threat of chronic pollution on the fisheries resources of restricted sections of these coasts cannot be dismissed. Although adult fishes may hardly suffer, nursery areas may be seriously affected as a result of smothering or poisoning of the multitudes of small organisms living in and on the top layer of the sediments on which juvenile fishes and shrimp feed.

Generally, fish do not suffer directly from sinking of oil but may acquire an aberrant flavor by feeding on benthic organisms carrying oil droplets. Even if the area were an important feeding ground for fishes of commercial importance, an appreciable mortality would not occur among such fishes, but they might become tainted, which would affect the fish industry economically.

Where spills occur in spawning grounds, sinking of oil may have serious adverse effects during or shortly after spawning periods for a species like the herring, which deposits its eggs on various bottom objects. Nursery grounds that are located in shallow sheltered areas could be especially vulnerable when large quantities of oil destroy the food organisms for the juvenile fishes and shrimp. To date, however, this has not been recorded.

Communities differ greatly in the time required for reestablishment following catastrophes. Planktonic communities display seasonal changes and their generation times are measured in weeks or months, while some benthic communities require years to attain maturity. Presumably persistence of catastrophic effects would be much more enduring in a long-lived benthic community than in a planktonic assemblage.

The recovery of polluted areas varies greatly, depending on the flushing of the polluted area, the type of the sediments on the substrata, and the degree of isolation of its ecosystems and the kinds of organisms that form them. The time periods for recovery may vary from a few months to several years. In general, the initial stages of recovery are characterized by opportunistic species that are often very productive, with a much longer time required to restore the community to one that supports more long-lived species.

One characteristic of organisms composing an ecological community that may affect its stability and rate of recovery is, for example, a slow rate of reproduction or growth. Such a characteristic increases the vulnerability of a species or ecological community to damage from oil or any other pollution.

There are certain common species of planktonic larvae that live only in brackish regions of estuaries. If these drifted passively in the current, they would be washed out into the open Gulf and lost; instead, they dive deeper after drifting toward the mouth of the estuary and are carried by the deeper currents back up to where they were spawned in the brackish regions. Thus, if the estuary is an isolated one, almost all the recruitment of these organisms is from the offspring of the resident population. If this population were completely destroyed by pollution, recolonization by chance immigration from another estuary would probably take a long time. The resident population of estuaries provides shelter and food for the young stages of many commercially important marine organisms (shrimp, fish, etc.).

Partly because of their isolation, the ecological communities of coastal marshes and estuaries are particularly vulnerable to the activities associated with petroleum exploration and production. The dredging to install rigs and pipelines may severely alter an estuary, and changes in the hydrology that bring about a greater incursion of higher salinity water may have severe effects on the aquatic life attuned to a given amount of salinity.

There is very little data on the effect of oil on pelagic species. Without more research, it is clearly premature to conclude anything about the effects of oil on the open ocean.

Oil Spill Case Scenarios

The impacts considered throughout this section have been projected using our assumed oil spill figure of about 13,000 to 45,000 barrels. However, the following three hypothetical case scenarios involving large and small oil spills are presented to give perspective on the possible fate of an oil spill in the Gulf of Mexico. A large spill was modeled after the Santa Barbara blowout, but there are three cases regarding the fate of the oil, each case potentially affecting different resources. A smaller spill originating from a drilling mishap, pipeline rupture or barging accident has also been presented.

The large spill scenario is a rough estimation of the near maximum impacts resulting from a large spill. The many variables affecting the fate and impact of an oil spill make it extremely difficult, if not impossible, to predict the exact outcome of a large spill.

Large Spill Definition:

The spill will involve a total of 4.2 million gallons (100,000 barrels) of oil spilled over a 61-day period. The rate is 210,000 gal. (5,000 bbl.) per day for the first 11 days (2.31 million gallons or 55,000 bbl.) followed by a decrease to 37,800 gal. (900 bbl.) per day for the remaining 50 days. The figure of 100,000 barrels, rate and duration is similar to that reported by Allen and cited in Battelle Northwest (1970) during the Santa Barbara blowout. The largest spill reported in the Gulf of Mexico is 160,000 barrels (USGS, 1971), so although the impact of our hypothetical spill would be negative, it is not the maximum amount possible.

Conversely, the official U.S. Geological Survey estimate of oil spilled during the Santa Barbara blowout was 10,000 bbl. If this were true, the Santa Barbara blowout, in comparison with other OCS spills, would be far from a maximum OCS spill, and not a realistic spill from which to model a high case scenario. Because of the wide area covered and length of time that oil flowed during the Santa Barbara spill, it is more realistic to accept Allen's higher spill figures and consider them as a severe near maximum spill..

Small Spill Definition:

This is a spill of 500 barrels resulting either from a tanker accident, pipeline rupture, or platform accident. Rather than describing specific cases involving oil movement of various kinds, we will leave this a generalized spill which can be applied to any circumstance.

Although the high winds required to rapidly transport the oil slick to shore reduced its volatile toxic fractions faster than under calm seas, the detoxification would be less than if the slick drifted on the ocean for several days before it reached shore.

Although the large spill scenario uses a discharge rate to obtain oil masses at various times after the initial spill, through the lack of a better method, the oil mass spreading was determined by equations that deal with spill volumes rather than rates of discharge. These equations used to calculate the spreading of oil over calm water do not consider physical movement (wind, waves, current, and tides) in the calculations.

Tables A-10 and A-11 derived from Fay's (1971) and Blokker's (1964) equations respectively, give the areas over which the oil mass volume may spread.

Since Fay's and Blokker's equations do not consider ambient movement or discharge rate, it is probable that the slick lengths, which were previously considered maximum, are conceivable minimum slick sizes due to the nonconsideration of local physical forces within the equation.

The Blokker constant and oil and water specific gravities arbitrarily used are 1,000 and 0.85 and 1.00 respectively. The data from the two tables, derived from Fay's and Blokker's equations, agree fairly well for each specific spill volume except for the fourth case in each table. Therefore, it is inferred that the maximum distance an oil volume will spread, on calm water, for each of the oil spill volumes given in Tables A-10 and A-11 is correct.

Murray et al., (1970) indicates, "For a given oil spill incident the current speed largely determines the size a slick will reach". It is further indicated that high discharges may elongate slicks and that high current speeds (Chevron incident observed) minimize the slick size and enhance the rate of oil diffusion.

Fay et al. (1971) proposed that the maximum slick area can be related to the volume of the spill by the dimensional formula A in Table A-12.

TABLE A-10

Spreading of Oil; Volume Dependent*

Volume (gallons)	Area: Square Meters	Area: Square Miles	Diameter: Meters	Diameter: Miles
3.50×10^4	3.9×10^6	1.51	2.24×10^3	1.39
2.10×10^5	1.5×10^7	5.79	4.38×10^3	2.72
2.61×10^6	9.9×10^7	38.26	1.12×10^4	6.98
4.20×10^6	1.4×10^8	55.82	1.35×10^4	8.36

* Calculated from Fay (1970).

TABLE A-11

Spreading of Oil; Time Dependent*

Volume (gallons)	Time (hours)	Area: Sq. Meters	Area: Sq. Miles	Diameter: Meters	Diameter: Miles
3.50×10^4	4	9.58×10^3	0.37	1.09×10^3	0.68
2.10×10^5	24	1.01×10^7	3.90	3.59×10^3	2.23
2.61×10^6	264 (11 days)	2.59×10^8	100.	1.82×10^4	11.31
4.20×10^6	1,464 (61 days)	1.10×10^9	426.	3.75×10^4	23.30

* Calculated from Blokker (1968).

OIL SLICK CHARACTERISTICS

Oil Slick Area Dimensional Formula A
From: Fay et al., 1971

$$A\ (m^2) = 10^5\ v\ (m^3)\ 3/4$$

Where: A = area

m = meter

v = volume

Oil Slick Area Equation B
From: Blokker, 1964

$$\frac{(r_t^3 \quad r_o^3)\quad w}{3v(w \quad o) \quad o} = K_r t$$

Where: r_o, r_t = slick radius (cm) initially and after time t sec. Assume r_o^3 can be neglected in comparison with r_t^3.

v = volume of oil (cm^3)

t = time of spreading (sec)

w, o = density of water and oil respectively (g cm^{-3})

K_r = a constant for a given oil

Fay found that this formula compared well with some recently (1971) summarized field observations.

From Berridge et al., (1968) the equation from Blokker (1964) is listed as equation B in Table A-12.

The "Blokker" constants, K_r, are derived from the slope of the curves, of the variation of the radius ($r_t^3 - r_0^3$) with time as the oil slick spreads.

The Blokker constants, seen below, were derived from the slope of curves of slick spreading as a function of time for various crude oils.

Crude Oil Properties

Crude oil	K (about 9° C)	Specific gravity
Libyan (Brega)	1,085	0.829
Iranian heavy	750	0.867
Kuwait	1,480	0.869
Iraq (Kirkuk)	975	0.845
Venezuela (Tia Juana medium)	1,340	0.869

From Murray's analysis of the Chevron spill (March 1970) it is possible to determine the slick length and width of oil from a continuous source as a function of the rate of oil discharge and ambient currents. From one of Murray's graphs, Figure A-4, a spill rate of 2,500 barrels (105,000 gallons) per day with current velocities of 10, 25, and 50 cm/sec (0.22, 0.56, and 1.12 miles/hr) is found to produce slick lengths of 300,120 and 58 km (186, 77, and 36 miles). If it is possible to extrapolate Murray's analysis for the above current speeds, at a discharge rate of 5,000 barrels/day (210,000 gallons/day), the following slick lengths would be obtained: 1,166, 466, and 281 km (725, 290 and 175 miles). The comparable slick widths are given below.

	2,500 bbl/day	5,000 bbl/day
10 cm/sec	11.9 miles (19.2 km)	23.8 miles (38.40 km).
25 cm/sec	4.8 miles (7.7 km)	9.6 miles (15.40 km).
50 cm/sec	2.4 miles (3.8 km)	4.7 miles (7.60 km).

Case 1 Scenario

The spill occurs from a platform five to six km from shore directly off an intertidal area which has also been classified as an "area of special ecological significance". A drift velocity will be assumed to be 0.8 km/hr. (three percent speed in the area of 28 km/hr.) (USDI, 1972) and the slick will reach shore in about six to eight hours. This velocity is slower than the three to four knots implied by Battelle Northwest (1970) when they cited a Weather Bureau meteorologist who estimated that downwind oil slick drift ranged from 10 to 20% at the surface wind velocity and stated ". . . instances of skim layer shear were noted with surface oil moving rapidly past nearly stationary free floating debris suspended less than half an inch below the water surface." This assumed velocity is comparable with the experience in the Torrey Canyon during which the oil movement rate averaged 3.3 to 3.4% of the wind velocity.

Case 2 Scenario

This is a situation with negligible wind and current velocity which allows the oil to simply float and spread on the water for over a week before it finally goes ashore. As with the Santa Barbara blowout, the oil covers 1,295 square kilometers of open ocean, and does not reach shore until the 12th day when damage to the intertidal area is at a near minimum. A 805 km oil slick would be a very thin film with scattered patches of heavier oil (Allen, 1969).

Case 3 Scenario

This spill occurs during a period of maximum land derived sediment inflow which causes maximum oil settlement to the bottom relatively near the source of the spill. We estimate that 30% of the oil spill volume will settle to the bottom. In terms of volume, this is 63,000 gallons (1,500 barrels) after one day, 690,000 gallons (16,500 barrels) after 11 days, and 1.26 million gallons (30,000 barrels) after 61 days. We assume there is little current and wind, the oil spreads in the shape of a circle, and sinks to cover an area of bottom equal to that of the area covered by the surface slick in Case 1 Scenario. The area of bottom covered and diameter of the circle is shown in Tables A-10 and A-11.

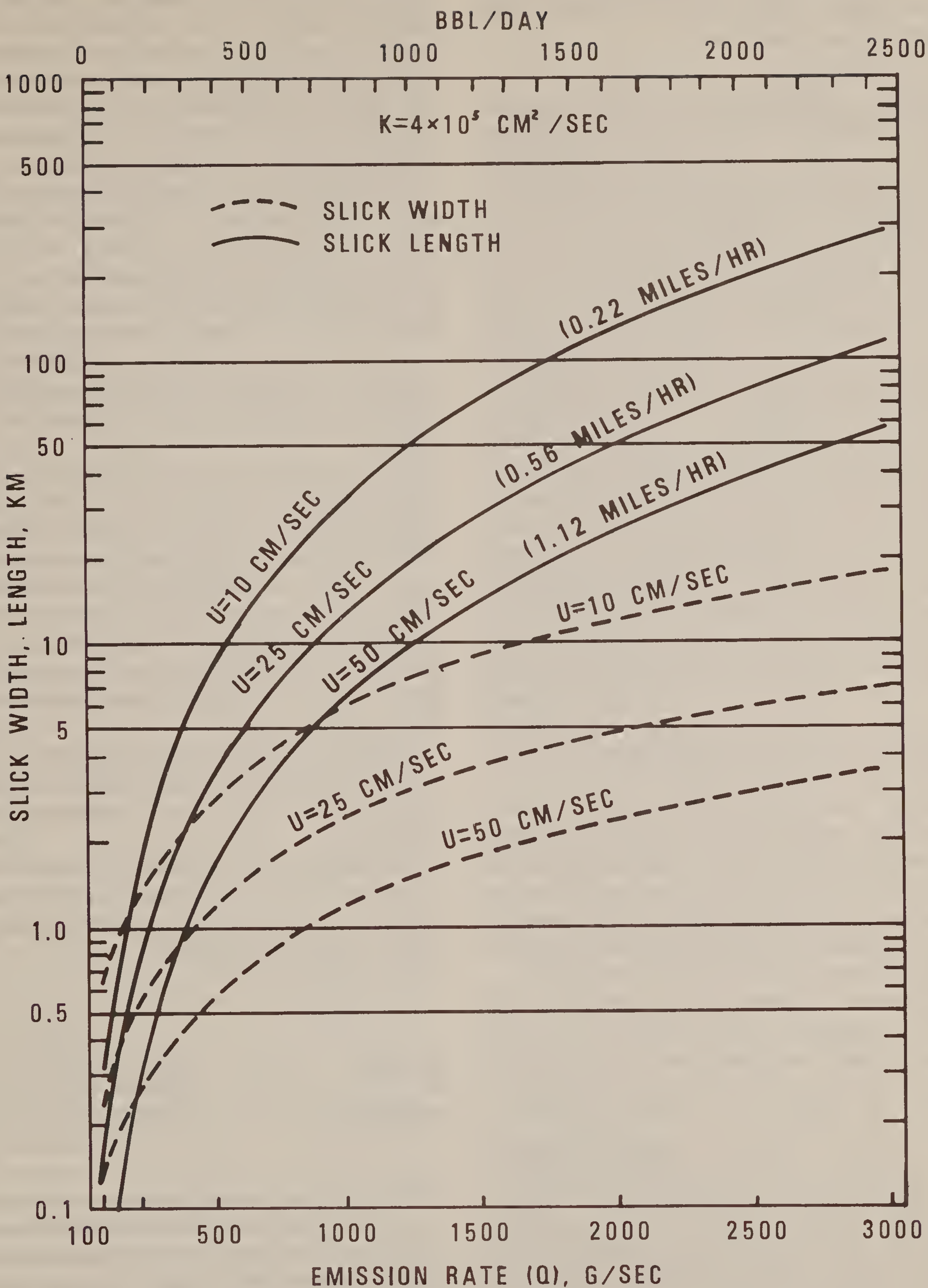


Figure A-4 Slick width (W) and slick length (L) as a function of rate of discharge (Q) for various values of current speed (U).

Source: Murray et al. 1970

Impact on the Living Components of the Environment: The Gulf of Mexico and Coastal Zone Regions

Impact on Plankton

Numerous phytoplankton and zooplankton species occur throughout the area of this proposed sale. The northern area of the Gulf of Mexico is similar to other tropical or subtropical bodies of water with respect to plankton composition and biomass (General Gulf, Visual No. 3).

The U.S. Geological Survey (USGS, 1976) estimated that there will be about 682 tons of drill cuttings discharged per each 10,000 foot well. They further estimate that from 25-75 exploratory and 100-300 producing wells may be drilled as a result of this proposed sale, requiring approximately 30-60 days drilling time for each test well and 45-80 days for each development well. In accordance with the code of Federal Regulations, OCS Order No. 7 the drill cuttings will be washed of oil. This mud contains a variety of materials, including waste products from various industrial processes. The basic ingredients of typical drilling mud consist of inert natural materials, i.e., bentonite clay, powdered limestone and barium sulfate. Some additives may contain materials which are not inert. Table A-1 lists ingredients of a characteristic sea water based drilling mud used to drill a typical well in the Gulf.

Since this mud will enter the marine environment through adherence to cuttings, accidents from drilling or overboard spillage from the drilling rig, a localized and temporary impact could occur at the discharge point. Recovery rates would be rapid due to the redistribution of similar species from adjacent areas by currents.

The discharge of drill cuttings and mud will produce temporary turbidity effects in the euphotic (lighted) zone; therefore, underwater illumination will be reduced in the immediate vicinity of the drilling rig. The effects of this activity, immediately adjacent to the drilling area, will be short-lived and highly localized, resulting in a decrease in primary production-photosynthesis by the local population of autotrophic phytoplankton. In addition, some planktonic filter feeding organisms will suffer physiological stress and death. However, both of these effects will not result in any measurable interference with the general level of productivity for each area adjacent to the drill rig. Redistribution of similar species from adjacent areas by currents will offset these minimal effects associated with drill cuttings and recovery should be rapid due to the localized nature of the impact. However, no specific study of this problem has been made.

USGS (1976) estimated that 161 kilometers of new pipelines will result from this proposed sale. Approximately 77% of the 61 tracts offered occur in water depths greater than 60 meters; no burial will be required unless the pipeline crosses the 60 meter contour shoreward. If pipelines are needed in the remaining tracts they will be buried. In areas where pipeline burial would be necessary, it would be accomplished by hydraulic jetting. This would increase the turbidity and the BOD loading in waters in the immediate construction area. Possible resuspension of toxic materials (e.g., pesticides/heavy metals) may also occur in coastal waters.

There may be a temporary decrease in primary phytoplankton production as a result of pipeline burial in offshore waters. This impact would affect local plankton populations, but should not adversely affect the functioning of the total marine ecosystem. The jetting barge is continuously moving while pipeline burial is being completed, therefore only a short time interval is involved and the area of impact is relatively small (approximately a 15 meter wide strip).

Pipeline construction in the coastal zone would have a similar effect on the estuarine species. No definitive study has yet been undertaken on this subject.

Assuming that the formation water would be discharged from the platforms into the Gulf, the following range of values for the denoted parameters have been documented:

Parameters	Range
Oil	6–827 mg/l (EPA, 1974).
Temperature	10–60° C (USGS, 1975).
pH	4.5–8.5 (USGS, 1975).
Suspended solids	12–656 mg/l (EPA, 1974).
Settled solids	0–125 mg/l (USGS, 1975).

The volume of water discharged from each platform varies; however, U.S. Geological Survey reported that a total of 322,570 barrels per day of produced water were being discharged as of October 1, 1975.

The resultant thermal, osmotic and chemical (contaminants and oxygen) stresses on indigenous plankton and neuston for offshore waters would probably be confined over a relatively limited

area near the discharge point in the euphotic zone of the Gulf in the vicinity of each platform for the duration of production phase. Effects include physiological stress from low dissolved oxygen and high concentrations of dissolved salts. These effects would occur a relatively short distance from the point of discharge, mixing processes would be expected to quickly disperse contaminants, and modify temperatures and salinities of the formation water to levels indistinguishable from that of seawater. Oxygenation of these waters to supersaturated levels would proceed rapidly. An unknown effect could be uptake of water soluble aromatics not removed in the separation process.

No effect from biological waste disposal is expected on plankton. OCS Order No. 8 requires that treated sewage effluent contain no more than 50 ppm BOD, no more than 150 ppm suspended solids and a minimum chlorine residual of 1.0 mg/1. Since the volume of this effluent released per day will be very small, no detectable effect on plankton is anticipated.

A breakdown of tracts offered, show that eighty-two percent of the acreage is gas prone, three percent is oil prone and fifteen percent is oil and gas prone. The probability of a major oil spill (greater than 100,000 gallons or 2,381 barrels) resulting from this proposed sale is uncertain.

Several pertinent studies have been conducted to demonstrate the effects of oil on plankton. It is possible to draw from these studies some general conclusions as to how phytoplankton and zooplankton will be affected if oil is present in the marine environment.

Ray and Mills (1974) and Mills (1974) demonstrated that once an oil spill episode has passed, only a few cells need survive to rapidly repopulate a given area.

The Gulf Universities Research Consortium (GURC, 1974) reported that the total cell counts/liter at the platform were much higher than at the control site.

The number of species of diatoms and dinoflagellates were found not to vary appreciably between the platform and control sites.

The GURC study (1974) also investigated two zooplankton communities in the bay and offshore areas of Louisiana. Neither diversity values nor biomass was significantly different between control sites and production/drilling sites whether in the bay or offshore. There have been no detectable changes in the calanoid copepod fauna of the total population during the past 20 years.

Mironov (1970) indicated that planktonic larvae of benthic and nektonic animals (meroplankton) are more sensitive than nature members of the plankton (holplankton). Therefore a threat to populations of various finfish and shell fish may exist in oil prone areas.

Oil coating of the various surface and actively vertical plankton species (i.e., large coelenterates) could have an adverse affect on planktonic populations (Moore et al. 1973). Neuston, which are strictly surface dwelling plankton, are clearly threatened, and active vertical migrators are potentially threatened.

The above literature indicate that the plankton populations of the Gulf of Mexico ecosystem will probably be able to absorb the impact of a major oil spill and recover rapidly. The greatest number of planktonic organisms directly killed from a spill of greater than 50 barrels would be found in the neuston or communities in the upper five centimeters of the Gulf surface. Since annual biological productivity is greatest in spring and winter, especially along the coast, in areas of upwelling a spill during this part of the year would do the most damage to planktonic productivity and the standing crop.

Impacts to planktonic organisms from chronic low-level discharge include direct lethality, reduction in photosynthetic efficiency, interference with chemical communication and general physiological stress to those organisms which are carried into a contaminated zone for that period of time that they are exposed to hydrocarbon concentrations above the effective level.

The impact from an oil spill could effect various populations of plankton in tracts that are prone to result in oil production. For this proposed sale, the following tracts have been designated as oil prone: 3, 36, 44, 45, 51, 52, 53, 54, 55, 56 and 57.

Impact on Benthos

Benthic assemblages and communities which exist in the area of this proposed sale can be broadly described as bay and sound, beach, shallow shelf, intermediate shelf, deep shelf and slope. Within these broad areas, more specific assemblages or communities can be described for shrimp grounds, oyster reefs, sand, silt and clay bottoms, and hard banks. This discussion will in-

clude all areas except beaches and hard banks which will be discussed under biologically sensitive areas.

The number of exploratory wells contemplated in this proposed lease sale are between 25-75. The volume of cuttings from each exploratory well of 10,000 feet would be approximately 1,687 barrels and would require about 10 to 14 days drilling; however, wells drilled in hard bottoms may require between 45 to 90 days.

Disposition of 682 tons of cuttings during drilling of each exploratory well will disrupt local benthic environments. Non-mobile benthic forms in the affected area may be smothered. We estimate that in the absence of toxic substances, recolonization of the substrate should begin after one reproductive cycle. The presence of hydrocarbons or drilling muds will retard this recolonization depending on the duration of the presence of hydrocarbons or other toxic materials. Recolonization should commence after a season's duration because of the absence of low concentration of toxic materials in most drill cuttings. If the bottom is different in texture and composition, it may be colonized by other components of the local population resulting in an altered species distribution. This could alter community structure in that part of the food chain which is dependent upon benthic species. This effect however would be highly localized.

We expect that coarser materials would comprise the bulk of the cuttings and possible cuttings mound, and that finer components would be distributed in response to prevailing currents and would grade into natural sediments of the immediate area. Benthic organisms and natural erosional-depositional forces would rework the sediments so that downstream cuttings deposition would be indistinguishable from surrounding sediments. The duration of the impact at each drilling location during and after drilling would be dependent upon: type of disposal; type of cuttings and size of area impacted; seasonal reproduction cycles and recolonization of indigenous species; time for colonization by different species from adjacent area; natural bottom sediment type, and volume of cuttings. A possible adverse effect to benthos might result from the loss of toxic drilling muds due to adherence to cuttings, accidents while drilling or overboard spillage from drilling rig. However, as previously mentioned, only a small percentage of this mud will enter Gulf waters. Because of its low concentration in drilling mud and the large dilution factor upon disposal, we expect the toxicity to benthic populations to be very localized and temporary at the discharge point, given that any significant quantity might reach the bottom.

Oil based muds are seldom used and are not considered in this discussion.

The area to be impacted from the discharge of drill mud and cuttings is dependent upon a number of factors: drill mud compositions and weight; water currents; sea conditions; type of disposal; velocity of materials through disposal pipe; water depth of disposal pipe and size of pipe; type of substrate being drilled or size of particles suspended; size of drill hole and volume of cuttings; geographic location of drilling platforms in the Gulf of Mexico; and dispersion rate of drilling muds and cuttings in water column.

Recovery rates would vary depending on the type and size of population impacted. In general, the initial stages of recovery are characterized by opportunistic species that are often very productive, with a much longer time required to restore the community to one that supports more long-lived species.

In water depths of less than 61 meters, new common carrier pipelines are entrenched by jetting away the sediment beneath the pipe and allowing the pipe to settle into the underlying trench approximately one meter. Partial burial takes place quite rapidly as the disturbed sediments slide and settle back into the trench.

The jetting process physically disrupts the sediments in its path and also causes resuspension of large quantities of sediment. This process would have the effect of displacing benthic organisms and would result in direct mortality to softer life forms, and indirect mortality to other through increased vulnerability to predators. Although recolonization would begin immediately, the native fauna could not be fully restored until seasonal reproduction cycles had been completed by representative species from adjacent areas; these would provide a supply of larvae to settle and enter the disturbed substrate.

Turbidity resulting from resuspended sediment is capable of producing an adverse impact on filter-feeding molluscan and crustacean benthos populations by clogging the filter-feeding apparatus or blocking respiratory surfaces. This impact is temporary, occurring during burial opera-

tions and lasting from several hours to a few days, and would effect those populations adjacent to the pipeline. Casual observation has revealed that ocean currents carry the sediment and redeposit it at various distances, depending upon the particle size of the sediment. Moreover, these same factors, along with the rate of the burial operation, determine the length of time in suspension.

Another possible source of impact during pipeline dredging is the resuspension of toxic heavy metals, hydrocarbons and pesticides that may have been deposited in the area by polluted rivers and/or land runoff, but the predictions for the occurrence, location, scope and duration of the impacts are unknown. The possibility exists that these toxic materials could be ingested by lower marine life and could then be magnified through the food chain until they would accumulate in serious quantities in top carnivores, including those species harvested for human consumption. However, the likelihood that this impact would occur decreases with distance offshore due to the distance from polluted rivers and/or land runoff.

Beyond 61 meters exposed pipelines will provide a hard substrate that will be quickly colonized in much the same way as platforms are colonized. This will result in a wider variety of organisms and greater biomass available for input into the food chain from settlement and growth of sessile epibenthos (fouling organisms). They will also act as shelter for more susceptible organisms or benthic larval forms.

Approximately 161 kilometers of pipeline may be required to transport oil/gas production from wells developed from this proposed sale. Locations of these pipelines are unknown. We expect that the area impacted is localized within 15 meters of the particular operations throughout the water column. However, this area may decrease or increase because of the following variables: water currents, sea conditions, water depth, natural bottom sediment and dispersion rate of bottom sediments from jetting operation.

Recovery rates would be dependent upon seasonal reproduction cycles and recolonization range from months to several years.

No effect from biological waste disposal is expected on benthic organisms. Since the volume of this effluent released per day will be very small, no detectable effect on benthic organisms is anticipated.

Assuming that the formation water would be discharged from the platforms into the Gulf, the following range of values for the following parameters have been documented:

Parameters	Range
Oil	6–827 mg/l (EPA, 1974).
Temperature	10–60° C (USGS, 1975).
pH	4.5–8.5 (USGS, 1975).
Suspended solids	12–656 mg/1 (EPA, 1974).
Settled solids	0–125 mg/1 (USGS, 1975).

These effluents will affect only surface and near-surface organisms and will have no impact on benthic organisms at the point of discharge because of the high dilution factor upon entering the Gulf.

Of the tracts nominated, 82% are gas prone, three percent are oil prone and 16% are oil and gas prone. The probability of a major oil spill resulting from this proposed sale is unknown as statistical data reflecting current technology is outdated. Other sources for oil spills are chronic low level leakage from production platforms and pipeline leakages.

The following is a synopsis of pertinent studies that have been conducted concerning the effect of oil on benthic organisms. These studies include both field and laboratory investigations. Thus, it is possible to draw from these studies some general conclusions to how benthic organisms will be affected if oil is present in the marine environment.

For discussion purposes, benthic fauna can be divided into; gastropods (snails, limpets, etc.), bivalves (oysters, clams, etc.), crustaceans (shrimp, crabs, lobsters, etc.) and all other fauna (worms, anemones, etc.). Apparently, gastropods are the most resistant to the toxic effect of petroleum and crustaceans are the most sensitive (Moore, et al., 1974).

Most gastropodal studies indicate a rather high resistance to hydrocarbon toxicity and periwinkles (Littorina littorea), a common intertidal snail, are apparently very resistant. The critical concentration may be 100-200 ppm or more. Limpets (Patella vulgata) demonstrate the only significant deviation and appear to have a critical threshold concentration of less than 5 ppm. The relatively high resistance of most gastropods may be due to secretion of a protective mucous substance (Shelton, 1972).

Bivalves, including oysters, clams, cockles and mussels, are moderately resistant to oil. The abili-

ty to close their shells and seal off the ambient water mass acts as an effective protection mechanism. However, this closed condition cannot be maintained indefinitely; in fact, cockles tend to "gape" making them more susceptible (Simpson, 1968). Typical critical concentrations for most bivalves are 5-50 ppm of petroleum hydrocarbons.

Both benthic crustaceans and other miscellaneous benthic organisms are apparently fairly sensitive to petroleum hydrocarbons. Threshold concentrations appear to be 1-10 ppm of petroleum hydrocarbons. Burrowing organisms may also be threatened by alteration in the substrate texture and structure.

On incorporation of hydrocarbons by benthic fauna, Blumer (1969) and Blumer, et al., (1970a) have indicated that bivalves exposed to oil may retain aromatic hydrocarbons for a period of months or perhaps indefinitely. However, Lee, et al., (1972a) demonstrated that the mussel Mytilus edulis accumulated several different petroleum hydrocarbons but released approximately 95% of these in a period of two weeks when returned to uncontaminated water. Lee and Benson (1973) stated that petroleum hydrocarbons resulting from a distant small spill were accumulated by Mytilus but members of the same population showed no contamination three weeks after the spill. Teal and Stegeman (1973) exposed oysters to 106 ug/liter of a No. 2 fuel oil for periods of up to 50 days. They found that short term accumulation was correlated with the fat content of the oysters. The maximum levels of hydrocarbons detected in oyster tissues were 334 and 161 ug/g wet weight for high and low levels in oysters, respectively. After one month in their post-exposure "cleaner" sea water system, the oysters still retained approximately 34 ug/g total petroleum hydrocarbons, but since there was a small amount of contamination in this system (11 ug/liter), continued low level accumulation could not be ruled out.

In addition, Anderson (1973) reported that oysters quickly purged themselves of oil when placed in oil-free seawater. This investigator used four different oils (South Louisiana crude oil, Kuwait crude oil, No 2 fuel oil and Bunker C oil) and two different oysters (Pacific and American oyster, Crassostrea virginica). Anderson, et al., (1973) also reported the same results for brown shrimp (Penaeus aztecus) and the sheepshead minnow (Cyrprinodon variegatus) using identical methods. Vaughan (1973) also reported that oysters quickly purge themselves of oil when exposure terminates and they are placed in non-contaminated seawater.

Corner, et al. (1973) observed that naphthalene is quickly detoxified and excreted by the spider crab (Maia squinade).

Coating effects are principally associated with the higher boiling point fractions of oil (for example, oil which has been weathered so that the more toxic fractions have evaporated). The effects are usually in the intertidal zone involving both organisms and substrates. The thickness of coating which causes mortality is not readily definable. Most species exposed to a coating of weathered crude oil are likely to be affected in some manner (Moore, et al., 1974).

The effects of habitat alteration or removal of species from an area involves intertidal and subtidal benthic species. Epifauna (species lying on the substrate) may be little affected by the physical presence of oil; however, infauna (species living in the substrate) can be expected to be more vulnerable to habitat alteration. Unfortunately, there is virtually no data on the relationship between the amount of oil present and the degree of suitability of the substrate for various species (Moore, et al., 1974).

Based on geographic locations of oil prone tracts for this proposed sale, and using classifications of benthic communities of Parker (1960) for offshore Texas and Louisiana, the following are areas with the highest potential for impact on benthic assemblages from spilled oil. Adjacent areas could also be impacted if the spill was not contained or cleanup procedures were inadequate. In addition, bottom sediment (Western and Central Gulf, Visual No. 3) are listed to help characterize the assemblage.

These assemblages include:

High Island—one oil/gas prone tract, silty sand.
South Marsh Island—one oil/gas prone tract, Inner shelf, clayey silt.
Eugene Island—two oil/gas prone tracts, Outer shelf, silty clay.
Ship Shoal—two oil/gas prone tracts—Intermediate shelf, clayey silt.
South Timbalier—one oil/gas prone tract, Intermediate shelf, silty clay.
West Delta—two oil/gas prone tracts, Inner shelf, Clayey sand and silty clay.
South Pass—one oil prone tract, Intermediate shelf, silty clay.
Main Pass—one oil prone tract, Intermediate shelf, clayey silt, silty clay and silty sand.

In the event of a large oil spill, certain benthic assemblages will be affected because of the water depth and associated turbidity of these waters. These primarily include the inner (shallow), intermediate (middle shelf I) shelf assemblages and intertidal or shoreward areas if oil reached the shore. The seaward assemblages are less likely to be affected due to dispersion and dilution of crude oil through the water column. Also, quick response clean-up procedures (i.e., skimmers and containment of an oil spill) will reduce the area impacted thus reducing the probability of oil reaching intertidal benthos. In the history of OCS leasing in the Gulf of Mexico no oil spill resulting from an OCS lease area has ever penetrated semi-enclosed embayments, estuaries or wetlands. Beaches will be discussed under biologically sensitive areas.

The recovery of contaminated areas varies greatly for benthic populations. Variables include flushing of the contaminated area, type of bottom sediments, the degree of isolation of its ecosystems and the kinds of organism that form them.

In summary, impacts resulting from: (a) Drilling will cause smothering and burial (especially near bottoms firm enough to support an epifaunal community) in the immediate area of drilling operation. Recovery will usually begin within months but biological recovery will not be complete for the epifaunal communities for at least several years. (b) Pipeline burial will result in community disruption and destruction in the path of the 81 to 161 km of pipeline corridor construction. Destruction will be minor except in depths of less than 61 meters. Even here destruction will probably be limited to a strip about 30 meters wide along the pipeline path. Recovery will be in a matter of days for the mobile benthic organisms and one to several years for sessile organisms. (c) Resuspension of polluted sediments will result if pipeline laying or drilling operation occurs by the outfalls of polluted bays, rivers or streams. Direct kill to benthic organisms will be of limited but unqualifiable extent and duration. Pesticides could be accumulated in the food chain as the result of drilling or pipeline burial in these areas. This could be detrimental to certain individuals at the top of the food chain, although no widespread population fluctuation will result from these operations. (d) A large oil spill with a maximal amount of sinking oil would be the most detrimental to subtidal benthos. Since the literature indicates oil spills cause a range from extensive destruction to slight or undeterminable amounts, it may be concluded that some destruction will occur as a result of a massive oil spill. (e) Chronic low level oil pollution also would affect benthic communities, to what extent has not been determined, because no long-term field studies have been performed.

Impact on Nekton

Five taxonomic categories represent the active swimmers or nekton for the Gulf of Mexico: marine mammals and reptiles, fishes, cephalopod molluscs and certain crustaceans, shrimp and swimming crabs.

Moore et al., (1973) hypothesized three mechanisms by which oil may impact the individual fish (nekton) and thus the size and distribution of fish populations. They are:

Egg and/or larval mortality on spawning and/or nursery grounds. Eggs and larvae may be affected by concentrations of soluble aromatic hydrocarbons in excess of 0.1 ppm.

Adult mortality or failure to reach spawning grounds if the spill occurs in a confined, narrow or shallow waterway necessary for migration or spawning. Anadromous (spawns in fresh water) fish crowding into an estuary would seem especially vulnerable to this hypothetical case.

Loss of local breeding population or ability to breed due to contamination of spawning ground, or the destruction of the nursery area by oil.

Adult forms of nektonic organisms will avoid areas of contamination from oil as a result of their locomotive ability (Nelson-Smith, 1973). Another study by Roberts indicates that although nekton may be the most dense in the impact zone in comparison with other depth zones, the densities are so small as to prevent recognition of a direct kill. In such a case, avoidance is not involved; however, the effect is the same with little or no impact.

The probability of a massive spill resulting from operation on the OCS impacting spawning or nursery areas will be minimal because of the low number (11) of oil prone tracts for this proposed sale, distances of tracts from shore, and the fact that in the history of OCS leasing in the Gulf no oil spill resulting from an OCS lease area has ever penetrated semi-enclosed embayments, estuaries or wetlands.

The occurrence of sublethal (i.e., masking or interfering with prey detection, reproductive patterns, social behavior) effects are uncertain, but have the possibility of being an important impact of oil production in the marine environment. Stu-

dies conducted to date indicate that the severity of these impacts is uncertain (National Academy of Sciences, 1973).

Drilling operations (i.e., discharge of drill cuttings and mud, and toxic material) will have a temporary impact effect on bottom-dwelling fishes or nekton (GURC, 1974).

GURC (1974) reported that drilling rigs have a disruptive effect on bottom fishes as compared to control areas. In shallow water areas, in Timbalier Bay, drilling operations had a very pronounced effect on the presence of the majority of the species in the area, such as: Groupers and king whiting. The fish species temporarily moved out of the vicinity of the drilling operations. This was also true offshore but to a lesser extent. This adverse effect is obviously localized and temporary as evidenced by the fact that the makeup of the area's fish populations has not changed since the oil drilling began.

This temporary disruptive effect will exist for pipeline placement and burial. These organisms will be exposed to increased turbidities and BOD, and possible resuspension of toxic materials.

No impact from biological waste disposal is anticipated due to the small amount discharged.

Another impact resulting from the placement of exposed pipelines and production platforms is that they serve as artificial reefs. They provide: Food in the form of encrusting algae, bryozoa, crustaceans and sponges; shelter in the various nooks and crannies, where juvenile fishes can escape predators; and visual orientation. Although orientation is not fully understood, the physical presence of objects in open water is widely acknowledged to attract many species of fish such as: Groupers and red snapper.

Dr. J. B. Thompson, investigating for the Gulf Universities Research Consortium (GURC, 1974), found no evidence of either harmful or beneficial effects on the fish and shellfish fauna on the open shelf as a result of the placement and maintenance of the offshore oil platforms. His study included the most abundant bottomfish trawl fauna of north central Gulf of Mexico, located between longitudes of 89°30′ N. and 92°30′ W. in depths of 18 to 137 meters, across the continental shelf off the coast of Louisiana. The dominant species studied included croaker, spot, scup, cutlass fish, sea carfish, sea trout, ground mullet and lipid fish. Dominant invertebrates included offshore blue crabs and brown and rock shrimp. Dr. Thompson used data from the Bureau of Commercial Fisheries (now the National Marine Fisheries Service), gathered by the M/V Oregon and other chartered vessels during the period 1950-65. This period saw the rise of the offshore oil industry in the study area. Dr. Thompson also stated that no trends were apparent throughout the period in either quantity or distribution of species studied. He also found a general trend toward diminution of trawl catch from east to west across the study area, which he attributed to current patterns and bottom type differences.

In summary, data thus far accumulated do not indicate negative impact on nekton from the placement and maintenance of the offshore oil platforms.

Impact On Food Webs

A majority of hydrocarbons do not accumulate in the food web; this is indicated by the fact that organisms have the ability to depurate at least a majority of these hydrocarbons. However, the possibility exists for the build up in organisms of selective hydrocarbons and non-hydrocarbon components that occur in oil. Substances such as naphthalenes and benzopyrene have been found to accumulate in mollusks in a relatively short time. Although accumulation can occur, magnification does not occur; however, greater than normal levels of aromatic hydrocarbons could be passed on the next tropic level. The impact on the predator is unknown, but it would depend upon the concentration in the prey, frequency of consumption, and the type of hydrocarbon within tissues of the prey.

There is ample evidence which indicates that heavy metals accumulate in the marine food web in a variety of organisms at the various tropic levels and through a variety of uptake pathways. The concentration factors reflect the abilities for marine organisms to concentrate elements from very dilute solutions in sea water.

Magnification of heavy metals such as PCB occurs because they are relatively resistant to chemical and biological degradation. Most of the incidents of high levels of heavy metals found in marine organisms in the ocean occur in coastal waters and point sources near pollution sources from land. The toxic effect on a consumer can result from feeding on organisms further down in the food web that have an effect on that organism.

Studies by Windom et al., (1973) indicate that copper, cadmium and zinc concentrations were similar in all fish studied except for the small plankton- eating fish (anchovies, etc.) which had much higher concentrations of these metals. This indicates that these metals are depleted up the food chain rather than magnified.

Evidence has been presented which shows that heavy metal concentrations in petroleum, formation water and drilling fluids can range from 10 to 10^5 times the natural background levels of the open ocean. These materials are diluted in seawater and can be absorbed by some marine organisms to various degrees. Therefore, there could be some uptake of metals especially by the sessile organisms around the platform. It is not known to what extent this occurs and to what level the heavy metals become concentrated. Benthic invertebrates are an important food source in both larval and adult forms. Therefore, their position in the food web makes them an important source for contaminants.

The input of heavy metals to the marine environment and accumulation in the food web due to offshore petroleum operations should be far less significant than sources of heavy metals from land in the coastal waters such as sewage effluent. Since the effects of heavy metals input from offshore petroleum operations into the marine food web are unknown.

Impact on Biologically Sensitive Areas

For the purposes of this section, biologically sensitive areas for this proposed sale area include shoreline and underwater banks.

Shorelines

Shorelines in the Gulf range from sandy to muddy, except for small and widely scattered pilings and jetties. Impacts on the shoreline could result from contamination by spilled oil.

The construction activity expected for the proposed sale may require new pipelines to transmit oil and/or gas to onshore facilities. Eighty-two percent of the tracts are estimated to be solely gas prone with three percent estimated as oil and the remaining fifteen percent as oil and gas.

During pipeline laying operations, pipelines are buried by jetting up to a point in which the jetting barge would be in danger of shoaling if further progress was made. From this point on, the pipeline is usually buried by use of a suction, clamshell or bucket dredge. As this operation crosses the beach, it will disrupt and rework the substrate for a width of approximately nine to twelve meters.

Another possible source of impact during pipeline dredging to shorelines is the resuspension of toxic heavy metals and persistent pesticides that may have been deposited in the area by a polluted stream and land runoff. The possibility exists that these toxic materials could be ingested by lower marine life, and then be passed through the food chain, to higher forms of life, including man.

Rutzler and Sterrer (1970) have pointed out that sandy shorelines (beaches) have a horizontal rather than vertical extension and a large "internal" surface. Therefore, they act as high natural filters for the water transported in by waves and tides. In the case of an oil spill, large quantities of oil will be pressed into the sand, mixed with the subsurface return flow and then transported to other areas. Rutzler and Sterrer (1970) found a large apparent decrease in the total number of species present in oiled sands, although they were unable to prove that this was a result of spilled oil due to a lack of baseline data.

During the Arrow spill study (Operation Oil, 1970), excavation of clams revealed oil extending down most burrows and often forming a pool at the bottom. Clams generally moved up the burrow to evade the pools, and sometimes left the entire substrate. Some mortality occurred and even the live clams were morbid, although they recovered with prolonged exposure to air.

Mackin (1973) stated that the effects of oil in the intertidal zones, beaches, marshes and rocky shores are sometimes severe. The area of the beach zones is subject to heavy concentrations of oil and may be damaged if certain levels are reached.

In the event an oil spill reaches a piling or jetty, damage to the benthic community is expected. Damage would depend on the level of concentration of the crude oil.

In summary, if oil were to be deposited on the moderate or low energy shoreline of the Gulf of Mexico, there would probably be a substantial kill of infauna. Removal of oil by natural means would probably be a very slow process and would require redistribution of the sand by storm tides and high-energy storm surf. Recovery rates would range from months to years depending on reproduction cycles, recolonization and extent of contamination.

Once a spill arrives ashore, it is generally too late for complete and instantly effective mitigative measures, and the cleanup operation itself may have unfavorable impacts.

Four oil prone tracts (54, 55, 56 and 57) located around the Mississippi Delta may have the highest probability of causing damage to shorelines through accidental oil spills.

Reefal features

Three tracts, 10, 11 and 61 contain all or part of an offshore fishing bank.

We have proposed that these tracts be offered with protective environmental stipulations (see Mitigating Measures Included in the Proposed Sale) promulgated for other fishing banks. These stipulations specify requirements for the protection of fishing banks which must be satisfied before any drill sites, pipelines, rigs, platforms and any other development operation will be approved.

We feel that these stipulations are adequate for protection of these banks from direct adverse impact. However, the potential for long term, indirect impact from drilling and production operations on such features as reefs and banks is insufficiently known to allow prediction at this time.

Impact on Vegetation

This section will treat only that vegetation in the coastal area which may be affected by an oil spill from a well or pipeline. This includes only those environments that are inundated regularly or periodically by tidal action which may expose the vegetation to pollutants.

There is approximately 175 km of coastal marshland along the Mississippi Delta region that is subject to impacts resulting from sporadic accidental oil spills, from chronic oil pollutants, and from pipeline construction. Tanker operations are not expected to result from this proposed sale. Therefore, accidental oil spills will be related to oil washed ashore from platform accidents or pipeline ruptures.

Numerous papers have treated the effects of a single oiling on emergent marsh plants. These reports discussed marshes located in several different regions of the world; however, the general vegetative groups are similar and most are of the same genera. Thus, it is possible to draw from these studies some general conclusions as to how certain plant genera will be affected by potential oil spills.

Fuel oil spills at West Falmouth, Massachusetts and Chedabucto Bank, Nova Scotia, resulted in severe damage to many marsh organisms as reported by Burns and Teal (1971) and Thomas (1973), respectively. The plant most severely affected was the cordgrass Spartina, a perennial plant that plays an important role in aeration, sediment stability and nutrient recycling in marsh ecosystem. In the Chedabucto Bay spill, the heavily oiled areas showed very little recovery of Spartina after two years.

Less attention has been given to chronic pollution within the marsh environment. Baker (1971b) provided some data on this subject. In an experimental marsh area, test plots were subjected to oilings at various intervals. In general, recovery from up to four oilings was good, but above this amount, there resulted a rapid decline in vegetation. This tolerance varied some by different plant species. Baker also believed that marshes could probably survive two or three oilings a year, provided that a long recovery period followed.

More insidious effects can be expected in areas of chronic pollution. Studies by Nelson-Smith (1973), Baker (1971b) and Crapp (1971) on the salt marshes of South Wales showed that refinery discharges, even if in low concentration (10 ppm), will in a matter of a few years, because of its continuous flow over extended periods of time, kill all the vegetation in the affected area. The damage to Spartina is caused by the accrual of oil on the surface of the leaves which prevent the transfer of oxygen within the plant tissue, thus resulting in severe oxygen depletion around the roots. The killing of Spartina led to the subsequent erosion of the marsh and the loss of a portion (38 hectares in the Nelson-Smith study) of the marsh habitat.

In general, there are many variables involved (oil type and amount, season of the year, cleaning treatment and species of plant) that influence the degree to which marsh vegetation will usually recover from acute oilings with adequate recovery time. The possibility for serious short-term (less than one year) impacts to the marsh vegetation is possible in the event of an oil spill resulting from this proposed sale.

Five of the oil prone tracts included in this proposed sale are in close enough proximity to the coast that they could allow an oil spill or chronic pollutants to enter the marsh environment. These include tracts 3, 54, 55, 56 and 57.

Gagliano (1972) has identified several adverse impacts to marshes as a result of pipeline canal dredging. These include primarily the disruption of marsh vegetation, salt-water intrusion, accelerated run-off and increased tidal exchange. Any one of these impacts have the potential to reduce a marshes' productivity or to alter the floral and faunal components. The duration can be expected to be short-term (less than one year) if the area is rehabilitated upon completion of the pipeline. However, impacts could result for several years if no effort at reclamation is made.

The extent to which an area's ecosystem may be influenced is partly dependent upon the number and location of pipelines coming ashore, and the recovery of the right-of-way after completion. Generally, it is advantageous for industry to utilize existing pipelines whenever possible in order to reduce expenses and also to eliminate unneeded disturbance of resources. From the estimated 20-40 platforms that may be generated as a result of this proposed sale, 161 kilometers of pipeline are estimated to be required. It is anticipated but now known that production from this sale proposal will be connected to existing facilities and the probability of pipelines coming ashore is remote. Therefore, no adverse impacts resulting from transportation of crude oil or gas, storing, and refining activities would be incurred to marshes, either immediately or cumulatively, should this proposed sale proceed.

Impact on Wildlife Species

BIRD SPECIES

Considerable data are available concerning the impact of oil on various species of birds. According to available data, it appears that birds generally suffer the same physical and physiological symptoms when contaminated with oil as other fauna. Therefore, mortality and damage to bird species, as described by Bourne (1968), can be expected for those fauna which have been coated with oil. Hydrocarbon contamination destroys the insulation and waterproofing ability of the affected birds' plummage. Not only is the bird subject to heat loss and pneumonia in this condition, but it may also lose buoyancy. In addition to the external effects, internal disorders can result from ingestion of the oil during preening or feeding.

Menzies (1973) summarized 42 oil spills exceeding 50 barrels in the Gulf of Mexico between 1964 and 1973. No indication of any bird losses were noted, although it is possible some loss may have gone unreported since Clark (1973) reviewed several papers that suggested that less than 25% of bird corpses never reach shore if killed at sea. Based on the above information in addition to the low probability of a large oil spill, this proposed sale should not adversely effect pelagic birds; however, this possibility cannot be entirely ruled out.

Bourne (1968) discussed the probability of certain groups of birds being more susceptible to becoming coated with oil than others. He believed that aerial species would not deliberately dive into the oil and that coastal species may paddle over or squat in oil on the shore, but they would receive minimal damage. It was suggested that swimming species were the most vulnerable since they would probably not notice the oil until they swam into it. The latter would include many of the waterfowl group.

Shore birds (gulls, plovers, etc.) by nature spend a good part of their daily activities feeding and resting on the beach or shore environment. The effects of oil on shore birds has been documented by numerous investigators. Straughan (1970) and Drinkwater, et al., (1970) reported the impact of the Santa Barbara oil spill on bird life. Their data indicated that during an oil spill shore birds faired much better than some other groups of birds closely associated with the marine environment. From mortality figures on 432 birds, less than 20 were classified as shore birds.

Hartung and Hunt (1966) investigated the impact of oil ingestion by waterfowl in addition to the effect of their physical contact with oil. It was determined that lethal doses of lubricating oil ranged from 1 ml to 4 ml per kilogram of body weight. Therefore, a duck that acquired a coating of seven grams of oil and preened about 50% of this could easily ingest a lethal quantity. A definite correlation cannot be made concerning the relationship between the waterfowl death and the lubricating oil and crude produced in the Gulf of Mexico. However, it is presumed that sufficient quantities of ingested crude would cause death. The probability of this cannot be estimated; however, in reality, the chance of this occurring is considered low.

External effects of oil are not the only detrimental impact possible to birds. Hartung (1965) demonstrated that duck eggs treated with 2036 mg

of medicinal oil (presumably non-toxic) indicated a hatchability of 20% as against 90% in controls. In addition, none of the 19 eggs incubated by those ducks which were smeared with oil on their undersides hatched. Ingeting oil-contaminated food also halted laying and suppressed reproductive behavior. Rittinghaus (1956) reported an incident in which the eggs of numerous terns and other shore birds failed to hatch after the parents had become contaminated with oil.

The possibility does exist for significant damage to occur to marsh and shore birds should an oil spill reach the shore and contaminate the birds or their habitat. In view of the distance from shore in which most of the oil prone tracts are located, this possibility is significantly reduced. However, there are five oil prone tracts (3, 54, 55, 56 and 57) that are close enough to shore to pose a threat to nesting birds should an oil spill occur.

Indirect impacts to shore and marsh birds could include temporary loss of habitat due to pipeline construction, and permanent loss due to the construction of onshore facilities. This impact is also felt to be improbable since no new refineries are anticipated and most, if not all, new production from this proposed sale will come ashore in existing pipelines; therefore, no impact is anticipated from refining construction.

COASTAL/AQUATIC MAMMALS

A review of the current related literature indicates that there has been little research of the effects of acute doses of crude oil on mammals and other species inhabiting marsh habitats. Peller (1963) and Wragg (1954) observed various oilings of muskrats and beavers. Generally, the insulating properties of the fur of aquatic mammals can be expected to be destroyed upon being coated with oil, and later results in illness or death.

Nelson-Smith (1973) stated that since mammals have an impervious skin and breathe air, opportunities for toxic components of oil or emulsifiers to exert a physiological effect are largely limited to their ingestion during preening, grooming, and perhaps feeding. Irritation of the eyes or exposed mucous membranes may also be common to contaminated individuals.

In view of the general proposal of this sale, the probability that an oil spill will reach shore is considered remote. However, five oil prone tracts (3, 54, 55, 56 and 57) which are close enough in proximity that an oil spill could reach shore and create an adverse impact to the wildlife species.

MARINE MAMMALS

Data are not available from the Gulf of Mexico to estimate the impact of offshore production on marine mammals. However, the impact would appear to be a function of the probability of an oil spill and the population size and distribution of the species. Therefore, it is improbable that leasing will effect marine mammals in the Gulf to any extent because these species do not appear to be abundant in the Gulf, thus reducing their chance of exposure to oil contamination.

UPLAND WILDLIFE

No direct impact is anticipated to Upland wildlife as a result of this proposed sale. However, there may be an indirect impact as a result of habitat loss, should an onshore storage facility be constructed.

Impact on Endangered Species

Several endangered species occur within or in close proximity to the proposed sale area. The following discussion will treat those species classified as "endangered" by the U.S. Fish and Wildlife Service and are depicted on Visual No. 4 of the Western and Central Gulf.

A small breeding colony of Brown Pelicans (50 pairs) has been established on Grand Terre Island, Louisiana, and appear to be making a comeback as a resident population. The Brown Pelican wintering population enjoys a wider distribution through the central Gulf. Two nesting rookeries are also identified along the Texas coast (Western Gulf, Visual No. 4).

Possible impacts on the Brown Pelican as a result of offshore leasing include the possibility of becoming contaminated with oil, and ingesting oil-contaminated food. Since this species does depend totally on the marine environment, the possibility of it becoming oiled or ingesting oiled food organisms is a possibility in the event an oil spill does occur in close proximity. However, for this proposed sale the nearest oil prone tract (54) is approximately 16 km from shore, therefore the chances of oil impacting the birds or their habitat is low. It is not expected that an occurrence of this nature would be detrimental to the total population in the State, since the Brown Pelican does not spend all of its time in the water and is not constantly exposed to pollutants. Any bird that would contact the oil, however, would be susceptible to illness or death.

The possibility for consuming oil contaminated food organisms is a very real possibility since the pelican feeds on fish species. No data is available concerning single or accumulative doses of petroleum derived hydrocarbons. A massive dose could result in death.

The red wolf inhabits the coastal prairie in southeast Texas and southwest Louisiana. No direct impacts to the wolf are anticipated from offshore leasing.

The alligator, for all practical purposes, inhabits the entire coastal area of the Central Gulf. They are primarily a species of the fresh water environment, but occasionally inhabit brackish marshes. It is not anticipated that acute or chronic discharges of oil would adversely affect the alligator to any extent.

Sea turtles in the Gulf include the Atlantic ridley, hawksbill, leatherback. The principal impact that may affect the turtles as a result of offshore leasing is oil washing ashore and possibly contaminating the eggs or hatchlings. Both of these possibilities are remote, however, since the eggs are generally well covered with sand and the hatchlings are exposed for only a very short time to the beach environment once they emerge from the shell. Any loss that would occur may seriously reduce future nesting populations. Individual turtles could be coated with oil if they emerged into an oil slick, however, this would also be a remote possibility. Leasing as a result of this proposed sale would not affect the sea turtle population on an cumulative or immediate basis.

The southern bald eagle, also not shown on Central Gulf, Visual No. 4 maintains a fragile nesting population in coastal Louisiana. The location of these nesting sites are not in the vicinity of any oil prone tracts for this proposed sale, therefore, no impact is expected.

Impact on Commerical Fisheries

Offshore oil and gas operations interfere with commerical fisheries in the following ways: removal of sea floor from use; underwater obstructions; oil pollution (chronic or accidental); pipelines and reefs (man-made and natural). Probably the commercial fisheries most affected would be menhaden and/or shrimp trawling in the nearshore areas. Because some of these trawling areas are already heavily developed.

Removal of Sea Floor From Use

This impact involves navigational problems to commercial fishing fleets and reduces the area of sea floor for trawl fishing. Since the majority of shrimp and commercial bottom fish are caught by dragging large trawls across the sea floor, sites occupied by drilling or production platforms and attendant service boats and barges must be avoided. If the structures are jack-up drilling rigs or permanent production platforms, the area of the sea floor removed would amount to one to two hectares for each structure. In deeper waters (over 91 meters), a semisubmersible drilling rig with its anchoring system would occupy up to 66 hectares (assuming a 457 meter anchoring radius). Trawling depths range from approximately 9 to 82 meters; therefore, structures beyond the 82 meter depth would have a minimal impact on trawling operations. The duration of exploratory drilling ranges from approximately 45 days for a single well to around six months for multiple well explorations. Permanent production platforms may remain in place for 10 to over 20 years.

The probability that permanent platforms will be erected on any leased tract, based on past exploration success rates, is about 32% for offshore Louisiana.

Approximately one out of three tracts will require a platform (or platforms). It is estimated that each full tract (2,331 or 2,023 hectares) developed will average two platforms. Using the actual dimensions of a platform, two per tract would physically cover approximately 0.02% (0.4 hectares) of each tract's sea floor. Taking into account a navigational safety zone around each structure and using the one to two hectares per platform figures, trawlers may be denied up to 0.2% (four hectares) of the sea floor per developed tract assuming two platforms are erected. The number of new platforms expected from this sale ranges between 20-40 therefore, the maximum area denied fishermen would be 160 hectares for the duration the platforms are in place. Location and water depth of these platforms is unknown (i.e., placement on shrimp grounds); however, stipulation c (Mitigating Measures Included in the Proposed Action) concerning the limiting of structures will be considered when planning the placement of structures. In this manner, fishing interests at any particular proposed development site can be considered in detail on a case-by-case basis. In addition,

offshore rigs and platforms present navigational problems to fishermen. Boats engaged in trawling will be inconvenienced by having to navigate around fixed structures and there exists the possibility of fishing boats colliding with structures.

A Coast Guard summary for the period July 1, 1962 through June 30, 1973 reported ten collisions of fishing boats with offshore structures. Causes of these collisions were personal neglect aboard fishing boat (5), equipment failure on boat (1), equipment failure on rig (3) and insufficient and improper light of rig (1). There was only one injury, total damage to boats amounted to $151,000 and damage to platforms $24,000.

It is obvious that commercial trawling may be adversely affected to some degree for the next few years because of reduction in trawlable grounds; however, the extent of this is not known but will be more cumulative in nature. There are no data to indicate that offshore exploration is responsible for any decline in catches at present. There is reason to expect that with an increase in the number of platforms, the chance for increased fishing boat collisions with these platforms will result; however, this is unquantifiable.

Underwater Obstructions

Underwater obstructions or completions have little ecological importance but may cause problems to trawlers. The obstructions referred to here are, submerged well heads, underwater stubs, and large pieces of debris which when snagged, may cause damage to trawls and nets.

The source and nature of underwater stubs is described in Appendix D-3 (USDI, 1975b, Vol. 3). As previously stated, Coast Guard regulations require that stubs be marked by a lighted buoy at the surface if there is less than 26 meters of clearance. Stubs with clearance of between 26 and 61 meters must be buoyed; however, a lighted buoy is not required. These buoys are frequently missing despite regular maintenance and replacement. Also, if in water depths of 26 to 61 meters, the stub is covered by a bonnet, then it need not be marked by a buoy.

Another safeguard has been the plotting of these stubs on navigation charts for vessels with accurate navigational equipment.

In addition Loran-A (navigation instrument most used by fishermen) readings have been recorded and published in numerous publications. Fishermen use these readings to avoid areas where stubs or obstructions may be located.

Large pieces of debris, such as equipment, piping, structural members, tools and the like, may accidentally be lost off a platform, service boat or barge. If this occurs near a platform it may be located by divers and retrieved as specified in OCS Order No. 8. However, if it is not lost from a boat or barge underway, the location may not be known accurately enough to allow its subsequent recovery.

The number of underwater obstructions is unknown; however, stipulation c (Mitigation Measures Included in the Proposed Action Section) concerning the limiting of structures is considered when planning the placement of structures. In this manner, fishing interests at any particular proposed development site can be considered in detail on a case-by-case basis.

Oil pollution (chronic and accidental)

St. Amant (1974) stated that chronic pollution from offshore production sites represents an unknown factor. Daily drips and loss of small amounts of oil or other chemicals overboard do not appear to generate ecological problems because of the immense water volumes compared to the small amount of oil lost. Whether such sublethal pollution levels will eventually accumulate and cause environmental degradation has not been determined.

Dr. J. T. Thompson, investigating for the Gulf Universities Research Consortium (1974), found no evidence to indicate either harmful or beneficial effects of the placement and maintenance of offshore oil platforms on the bottom fisheries on the open shelf. His study included the most abundant bottomfish trawl fauna of the north central Gulf of Mexico, between longitudes of 89°30′ N. and 92°30′ W., and 18-137 meters across the Continental Shelf off Louisiana. Dr. Thompson used data from the work of the Bureau of Commercial Fisheries (now National Marine Fisheries Service), with the M/V Oregon and other chartered vessels from 1950-65. This period saw the rise of the offshore oil industry in the study area. Dr. Thompson also stated that no trends were apparent through the period in either quantity or distribution of species studies.

Dominant fishes for the study included croaker, sport, scup, cutlass fish, sea catfish, sea trout, ground mullet and lizard fish. Dominant invertebrates included offshore blue crabs and the brown and rock shrimps.

In an area of a chronic oil spill, commercial fishing activities are inhibited in order to avoid contamination of fishing equipment, vessels and catch. Also long term deleterious effects could result. There are three particularly important ones, impossible to quantify: (1) If large amounts of plankton were destroyed the food web could be seriously disrupted and result in population crashes of organisms directly or indirectly dependent upon the plankton. (2) Entire year classes of juvenile or larval fish might be destroyed resulting in greatly reduced yields several years after the spill. Ketchum (1973) refers to Mironov's work in 1967, stating there was 100% mortality in developing flounder spawn at concentration, ranging from 1-100 ppm in three types of oils. (3) Oil pollution might lower organisms' resistance to disease and other environmental stresses. This could produce less robust, lighter weight individuals and an increased mortality rate over a long period of time, causing a slow, but marked decline in fisheries. Ketchum (1973) showed that abnormal development occurs following longer periods of exposure to concentrations as low as 0.01 ppm. (4) Fish may have to be discarded due to tainting of the flesh. One example was given by Connel (1971) who stated that the Australian mullet had a kerosene-like tainting due to the presence of kerosene-like hydrocarbons in the flesh. He found the contaminated compounds to be similar to substances isolated from river sediments. The river used by the mullet flows alongside oil refineries and associated storage and wharf facilities. Volatile hydrocarbons were found in the water adjacent to petroleum storage facilities and also in the river's estuary near a sewage fallout. Seatrout and plaice were also found to be tainted according to taste test. These fish were caught after the Torrey Canyon incident involving the spillage of Kuwait crude oil. No chemical analysis by chemical class was reported (Clark, 1973).

Numerous studies on the effect of oil on commercially important shellfish indicate that these invertebrates may both absorb, and to varying extents, clean themselves of hydrocarbons.

Oysters (*Crassostrea virginica*) may accumulate oil through feeding activity in a pollution zone. As the oyster feeds, it pumps water over a series of gill filaments which trap food particles such as phytoplankton. Hydrocarbons in the plankton may be incorporated in the oyster. Ehrhardt (1972) reported that oysters taken near the entrance to the Houston Ship Channel in Galveston Bay, Texas are contaminated with a high content of petroleum derived hydrocarbons. Because aromatic hydrocarbons are more soluble than paraffinic and naphenic hydrocarbons, the oysters most likely take up the aromatic fraction as a water solution through their gills, and as filter feeders by accumulation of particulate food matter. The author found the composition of oyster contaminants to be similar to many Texas crude oils, among them Conroe, Beaver Lodge and Lee Harrison crude.

Results from Blumer's (1971) study on more highly aromatic No. 2 fuel oil rather than on crude oil suggest that oil becomes part of the organism's lipid (fatty) pool. Blumer noted that the oil in specimens observed from a Massachusetts oil spill remained relatively, unchanged in composition or quantity. He reasoned that if the oil were localized within the digestive tract, a shellfish could eliminate it rapidly. But the persistence of the hydrocarbon over a period of six months, its presence in adductor muscle tissue and the lack of further degradation of these hydrocarbons indicated that it becomes part of the organism's lipid pool.

Anderson (1973) observed oysters (*Crassostrea virginica*) and clams (*Rangia cuneata*), exposed to southern Louisiana crude oil and No. 2 fuel oil, and came to a different conclusion. Anderson found that both aromatic and saturated hydrocarbons are released from the tissues more rapidly; maintenance in clean water for periods of 24 to 52 days was reported sufficient to cleanse the tissues of detectable levels of hydrocarbons.

Teal and Stegeman (1973) measured the amount of hydrocarbons remaining in contaminated oysters after their return to clean water and found that a concentration of 34 mg/g wet wt. persisted in a "stable" compartment. The authors concluded that, while the oysters would not retain non-biogenic (petroleum) hydrocarbons permanently complete removal would take a "considerable amount of time".

St. Amant (1973) reported that under field conditions, oily tastes generally occur in oysters when the substrate exceeds 500 ppm of hydrocarbon. He said "that if the oysters are removed to unpolluted areas and allowed several months of depuration they will eventually purge themselves of oil to a point where noxious tastes are not detectable". This of course, does not assure the absence of all petroleum hydrocarbons.

Scarratt (1971) has found that commercial species of scallops ingested spilled Bunker C oil. Subsequent chemical analysis revealed the presence of Bunker C in the mantle, digestive gland, adductor mussel and gonad.

Studies on the effects of petroleum hydrocarbons on shrimp are few. St. Amant (1973) referred to a concentration of oil of 10 ppt as being lethal to these organisms. He added, however, that to reach this concentration under field conditions, more than 3,000 gallons of oil per acre-foot of water would be required to meet the concentration. This concentration is rarely acquired except in the immediate area of a spill.

In summary, oil spills could have both short and long term impacts on commercial fisheries; however, no measurable effects have been observed for chronic or accidental spills of oil. Oil spills may physically prevent fishing in contaminated areas. Adult finfish are not normally killed outright, but possibly could suffer a long term decline due to lowered resistance to disease and environmental stress. Larval and juvenile fish could be killed in great numbers if a spill reached spawning or nursery grounds (i.e., estuary). Many fish not destroyed may be tainted with hydrocarbons and be unmarketable. Shellfish are more susceptible to contamination because of their inability to escape and their general filter feeding habits. Many larval and juvenile could be killed outright. Survivors could be tainted and unmarketable for long periods. Authors disagree on the time required for shellfish to cleanse themselves. Estimates vary from several months for complete depuration to six months with no depuration.

Additional discussion on the impact of oil on fisheries may be found in Impact on the Living Components of the Environment. These sub-sections also contain discussions on the impact of drill mud and cuttings associated with drilling operations.

Pipelines

BLM is presently conducting a thorough search for data pertinent to a better understanding of the problems of anchor and fishing gear hangups on pipelines. Reliable data relevant to this problem are needed to help determine what burial depths are sufficient to prevent damage. BLM through its permit authority, requires pipelines to be buried a minimum of one meter out to a water depth of 81 meters. Beyond this depth, pipelines are not required to be buried or marked by lighted buoys. Spokesman for the offshore pipeline industry indicate, through their experience in the installation and attempted maintenance of lighted and unlighted buoys, that a marker system in deeper water is extremely difficult to maintain. Heavy seas damage the buoys and their gear, and if sufficient slack is allowed to combat heavy wave action, then the buoy will not closely indicate the location of the pipeline. Compounding the problems is the history of alleged pilferage and vandalism which shortens the useful life of these markers. In any event, the data necessary for a determination as to the scope and significance of potential damage to fishing gear resulting from unburied and unmarked pipelines beyond 81 meters in depth has not been forthcoming from either the fishing industry or any government source. Snow (1974) in outling the pipeline policy of the Louisiana Shrimp Association states, "It is our opinion and recommendation, that within the 81 meter contour, all pipelines should be buried".

Furthermore, because of the small amount of pipeline planned for this proposed sale, and the slight risk of a snag presented by a pipeline, the costs involved in burial or marking of pipelines beyond 81 meters far outweigh the benefits. In addition, valves and taps are buried beyond 81 meters. Presently under development by National Ocean Survey and BLM is a program to chart all major offshore pipelines and flow lines. Several charts for regions of the Gulf of Mexico have how been issued. Hopefully, fishermen in the Gulf will find these charts useful.

Before BLM issues the permit for the right-of-way for any common carrier pipelines, and Environmental Analysis Record (EAR) is prepared to determine whether the action warrants the preparation of an Environmental Impact Statement. The EAR along with the application from the pipeline operator is used in the decision making process as to the possible adverse impacts that the action might have on the OCS. Although BLM has no authority inside the three-mile limit of jurisdiction, if a proposed pipeline requires a beach or marsh crossing, anticipated impacts upon the ecosystem are fully discussed in the EAR. In order to reduce the impact upon the beaches and marshes pipeline corridors must be considered as an alternate to random landfalls. In the event that affected States initiate pipeline corridor plans, BLM will participate in very possible way.

Kilegen and Harris (1973) studies the mariculture potential in estuarine oil-pipeline canals and reported that many of the closed-off canals in estuarine areas can be managed to produce annual crops of fishes and shellfishes of commercial and recreational value. Some canals have yielded high standing crops of several fish species and crabs. One of the most promising management techniques is that of using cage culture for a commerical fish species, such as channel catfish or pompano. This method of fish culture eliminates problems of predation, flooding of canals and harvesting. Sport fishes, such as speckled trout, red drum and others, with forage species, could be stocked and managed in the same canals. Another alternative would be to stock shrimp or oysters in canals, with fish raised in cages. The shrimp would eat waste material from under the cages, and oysters, grown on racks, would filter out algae and other foods from the canal waters. This system would provide maximum benefits from a relatively unused resource, increasing its commercial value by several hundred dollars per hectare. For these reasons, it is imperative that research be continued towards development of canal fisheries management techniques, so that these valuable resources will not be lost.

Reefs (man-made and natural)

Man-made reefs (in this instance) refer to those reefs created by the placement of platforms. These platforms serve as a haven and shelter for many types of fishes and invertebrates, mainly fouling organisms, GURC (1974) investigation reported these findings concerning the biomass associated with these structures: The platforms are sites of marked increase in biomass due to the "reef effect", over one to two orders of magnitude higher than other biotopes (Table B-1). Components of this increase are the fouling community and the fishes they attract which are responsible for this portion of the economically important sports and commercial fishery. A discussion on fishing banks may be found in Impact on Biologically Sensitive Areas.

Table B-1 Biomass Determination

	Timbalier Bay	Platform 54A	Offshore Control
Organic Carbon in water	8.3-14.5 gm/m^3	5.8 gms/m^3	5.1 gm/m^3
Hydrocarbons in water 1/	6.2 mg/m^3	3.3 mg/m^3	1.2 mg/m^3
Hydrocarbons in surface film	not studied	0.21-1.27 mg/100 grams	0.12-1.27 mg/100 grams
Hydrocarbons in sediments	161-341 mg/100 grams	145-412 mg/100 grams	145-412 mg/100 grams
Primary Productivity	not studied	1.07 gms/ m 2//day	1.03 gms/ m 2//day
Amphipods	8.75 gm/m 2/	24.2 gm/m 2/	17.7 gm/m 2/
Zooplankton	0.02-0.2 gm/m^3	0.3 gm/m^3	0.3 gm/m^3
Polychaetes	0.3-5.0 gm/m 2/	not studied	N.A.
Platform growth	N.A. 3/	3000 gms/m 2/ pile surface	N.A.

1/ Hydrocarbons from all sources, including petroleum, organic detritus, plankton, etc.

2/ Substantially higher offshore Louisiana than other regions investigated in the open Gulf and offshore Florida.

3/ N.A. - Not Applicable.

Impact on Air Quality

The quality of air over the proposed sale area could be degraded by several types of sources including exhaust emissions of stationary power units, service vessels and by the accidental release of oil and gas from wild wells.

An average composition (Levorsen, 1967) of natural gas from an onshore field (an offshore field would be similar) in Texas is as follows: methane 92.5%, ethane 4.7%, propane 1.3%, butane 0.8%, and pentane and heavier gases, 0.6% (small amounts of sulfur are usually present).

If a blowout should occur at a gas well and did not burn, the above gases in a comparable ratio would be released into the air. A typical Texas offshore well produces approximately one million cubic feet of gas per day. A blowout could reasonably be expected to release at least this much gas into the atmosphere. However, if the gas well were burning, combustion would be essentially complete and the emissions would consist almost entirely of carbon dioxide (CO_2), water, and any sulfurous gases would be oxidized to SO_2. It is impossible to predict the probability of this occurrence. Since essentially all of the components of natural gas are non-reactive, there would be little impact whether or not they are burned. Therefore, recovery of this resource for use as a fossil fuel could result in a positive impact in some areas by providing energy by the cleanest source to be utilized, thus helping to alleviate air pollution.

If a blowout at an oil well occurred and released crude oil into the water, the resulting impact would be substantially greater, as discussed in Impacts on the Living Components of the Environment. If the oil does not burn, a significant amount of it would evaporate. During the Chevron 1970 spill, it was estimated that approximately 15% of the 30,000 barrels (bbls.) spilled evaporated. At an average density of 310 lb/bbls, this incident would have introduced approximately 1.4 million lbs of hydrocarbons into the air. Some oil spills in the past have resulted in fires, however, the chance of this occurring is minimal. In fact, if this were to occur, emissions from the crude oil would be relatively low in reactive compounds.

A reasonable estimate of the range of emission, assuming complete combustion, that an oil well fire could produce per 1,000 bbls burned, might be as follows (Levorsen, 1958): CO_2: 340,000 347,000 lbs., SO_2: 620–34,000 lbs. (SO_2 emission would be less for Gulf of Mexico crude oil, which range from 0.1 to 0.5% sulfur), and NO: 660-10,000 lbs.

Combustion of oil would be incomplete; however emissions would contain a smaller amount of the above compounds, and would include such materials as volatilized petroleum, particulate carbon, carbon monoxide, nitrous oxide, sulphur monoxide, along with other altered or partially oxidized matter. There is no reliable way to predict in advance the relative volumes of each of these possible emissions because it would depend, among other things, upon moisture content of the air, wind speed, pattern of oil spray from wild wells, number of wells involved, chemical content and physical character of the oil itself, and types of equipment and materials other than oil that might also burn.

Massive spills from wild wells are not the only source of spilled oil. A number of minor spills during the first nine months of 1972 released over 800 barrels of oil. The net result is that a small amount of spilled oil is floating somewhere on the waters of the Gulf of Mexico almost continually. The evaporation of this oil may cause elevated levels of hydrocarbons in the sea breeze coming off the Gulf. At the present time there is no evidence as to the source of these materials.

An increase in refinery capacity will add to the total emissions of oxides of nitrogen, sulphur dioxide, hydrocarbons, carbon monoxide, hydrogen sulfide and particulates affecting air quality onshore. An increase of up to 30,000 barrels per day in refinery capacity and other petrochemical industries which process the predicted production resulting from this proposed sale would cause a small increase in emissions. However, oil produced as a result of this proposed sale may not necessarily create the need for increased refinery capacity and other petrochemical industries. Instead, it may take the place of oil that will not be furnished from domestic sources due to declining production or other factors. In summary, it cannot be accurately predicted the degree to which air quality will be deteriorated from refinery use as a result of production from this proposed sale.

Impact on Water Quality

During drilling and oil production the water quality of the Gulf may be altered and degraded in several ways. Many of the chemical and physical factors which will be transferred to the Gulf during various phases of oil production will represent potential hazards to water quality. These potential hazards of degraded water quality may be found to be insignificant or significantly adverse. The magnitude of these potential hazards should be answered by future research.

On September 15, 1975, the EPA published in the Federal Register (40 CFR 435) a notice of interim final effluent limitations guidelines and new performance standards for the offshore segment of oil and gas extraction point source category. These effluent limitations guidelines are concentration based as opposed to a mass per unit production base. It is indicated that the major source of waste waters generated by offshore facilities are produced waters. The major pollutant formations in the waste waters resulting from the oil and gas extraction industry are oil and grease, residual chlorine, and floating solids.

Several methods of treatment technology for waste water from produced waters may be employed to achieve final limitations. It is also noted that drilling muds and drill cuttings may be discharged if they are water based and their discharge does not result in free oil on the surface waters. Muds and cuttings that are oil based may not be discharged, and by 1983 new source performance standards will require no discharge of waste water pollutants into navigable waters for those wastes generated by produced water sources of this subcategory.

Limitations have established the quantity and quality of pollutants or pollutant properties which may be discharged by a point source subject to the provisions of the EPA (1975) (Tables D–1 and D–2).

Sewage will be treated in accordance with OCS Order No. 8, which requires that the treated effluent contain less than 50 ppm of bio-chemical oxygen demand (BOD), less than 150 ppm of suspended solids and a minimum of 1.0 ppm residual chlorine after a retention time of 15 minutes. Treated sewage of this type which has proper discharge diffusion should produce a minimum amount of water quality deterioration.

To some degree, bottom sediments would be put into suspension by the emplacement of reentry collars, blowout preventors, drilling platforms and other sea-bottom equipment. The magnitude and extent of resultant turbidity would be dependent on the type and grain size of bottom materials, the prevailing water current and the duration of the activity. Proposed lease areas should have a short term impact from resultant temporarily increased turbidity.

Water quality degradation is also effected by resuspension of sediment during pipeline construction and burial. The jetting away of the substrate from beneath the pipeline will result in suspension of sediment which may be rich in pollutants. The sediment plume will move away from operations in the direction of the current. The plume can reach proportions of several yards wide and hundreds of yards long if the substrate is exceptionally muddy. The duration depends on the particulate size, shape, and density of the material suspended and the water's turbulence. After construction, normal pipeline operations will have no effect on the water quality. Adverse long-term impacts can result when pollutants are resuspended in the water column.

During drilling operations, drill cuttings may be discharged into the Gulf. Most cuttings will consist of sandstone and shale fragments; however, some silt and sand size cuttings may be produced and discharged into the water. We estimate that 1,700 barrels of cuttings may be discharged during the course of drilling an average 10,000 foot well over a period of 10 to 14 days.

Drill cuttings discharged into the Gulf that could contain drilling mud if not properly washed, would be dispersed and fall to the Gulf floor. The accumulation density on the Gulf floor and the degree of turbidity resulting from drill cuttings will depend on the current and the water depth in the area of discharge. The increase in turbidity will present a short-term decrease in the water quality. This impact will be of low magnitude.

Drilling muds that are used during drilling operations will be discharged periodically or accidentally into the Gulf. No detailed studies have been made on the manner in which drilling mud chemicals and drill cuttings may contribute to pollution in the marine environment. However, water base muds, cuttings and other waste fluids can be considered pollutants when waste treatment is not utilized. Possible pollutant characteristics include:

Table D-1 Offshore Segment - Oil and Gas Extraction Industry

Effluent Limitations - BPCTCA 1/

Subcategory	Water Source	Oil & Greese - mg/l		Residual Chlorine mg/l
		Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed	
A. Near Offshore (State Waters)	produced water	72	48	N/A
	deck drainage	72	48	N/A
	drilling muds	2/	2/	N/A
	drill cuttings	2/	2/	N/A
	well treatment	2/	2/	N/A
	sanitary M10 3/	N/A	N/A	greater than 1 4/
	M91M 3/	N/A	N/A	N/A
	domestic	N/A	N/A	N/A
	produced sand	2/	2/	N/A
B. Far Offshore (Federal Waters)	produced water	72	48	N/A
	deck drainage	72	48	N/A
	drilling muds	2/	2/	N/A
	drill cuttings	2/	2/	N/A
	well treatment	2/	2/	N/A
	sanitary M10 3/	N/A	N/A	greater than 1 4/
	M91M 3/	N/A	N/A	N/A
	domestic	N/A	N/A	N/A
	produced sand	2/	2/	N/A

1/ BPCTCA, best practical control technology currently available.
2/ No discharge of free oil to the surface waters.
3/ There shall be no floting solids as a result of the discharge of these materials.
4/ Minimum of 1 mg/l and maintained as close to this concentration as possible.

Table D-2 Offshore Segment - Oil and Gas Extraction Industry

Effluent Limitations - BATEA and New Source 1/

Subcategory	Water Source	Pollutant Parameter - Effluent Limitations: Oil & Grease - mg/l: Maximum for any one day	Oil & Grease - mg/l: Average of daily values for thirty consecutive days shall not exceed	Residual Chlorine - mg/l
A. Near Offshore (State Waters)	produced water	No Discharge		
	deck drainage	72	48	N/A
	drilling muds	2/	2/	N/A
	drill cuttings	2/	2/	N/A
	well treatment	2/	2/	N/A
	sanitary M10	N/A	N/A	greater than 1 3/
	M91M 4/	N/A	N/A	N/A
	domestic 4/	N/A	N/A	N/A
	produced sand	2/	2/	N/A
B. Far Offshore (Federal Waters)	produced water	52	30	N/A
	deck drainage	52	30	N/A
	drilling muds	2/	2/	N/A
	drill cuttings	2/	2/	N/A
	well treatment	2/	2/	N/A
	sanitary M10	N/A	N/A	greater than 1 3/
	M91M 4/	N/A	N/A	N/A
	domestic 4/	N/A	N/A	N/A
	produced sand	2/	2/	N/A

1/ BATEA, best available technology economically achievable, not later than July 1, 1983.
2/ No discharge of free oil to the surface waters.
3/ Minimum of 1 mg/l and maintained as close to this concentration as possible
4/ There shall be no floating solids as a result of the discharge of these materials.

Acute toxicity to fish; high immediate dissolved oxygen demand; and high concentrations of organic carbon, total nitrogen, phosphorus, solids, chemical oxygen demand and chromium.

The production and discharge of formation waters (oil field brines) has been discussed earlier. Three components or properties of formation waters contribute to water quality degradation when released into the Gulf. These include: entrained liquid hydrocarbons, dissolved minerals salts, and absence of dissolved oxygen.

Depending upon the formation from which an oil field is producing, dissolved elements and their respective concentrations in formation water may differ. However, the components of each reservoir will usually remain constant unless leakage occurs from one reservoir to another.

Wells that are in an initial stage of production may have formation waters which represent 20-30% of the total extractable fluid. As the oil reservoir is depleted, the amount of formation water increases. The maximum amount of formation water produced during the life of oil production will be approximately 0.6 barrels of formation water per barrel of oil produced.

To determine water production, the peak oil production is multiplied by the maximum water to oil ratio. The maximum water to oil ratio does not occur during periods of peak production. The water to oil ratio should be less than one during peak production and near one toward the end of the primary production period.

Within the proposed lease area, the maximum oil production is estimated to be 100-200 million barrels of oil. This would be extracted over a twenty year period. The expected annual production of oil will be from 2.7-10.7 million barrels. Considering the maximum amount of formation water production (0.6 barrels of formation water per barrel of oil produced), approximately 1.6-6.4 million barrels of formation water per year will be produced providing that all the tracts are leased and developed.

In the Gulf of Mexico many platforms are disposing of treated formation waters where the treatment equipment puts out an effluent less than 25 ppm oil content, but many older platforms are not accomplishing this. Other locations only manage to meet the requirements of OCS Order No. 8, by releasing waters with entrained oil averaging less than 50 ppm. The range of oil concentrations discharged from surveyed production platforms in the Gulf ranged from 6-827 ppm (EPA, 1974).

Due to many factors which will contribute to the physical and chemical characteristics of formation waters, no estimate can be made to the extent of the impact from these waters. The characteristics of formation water can change during the oil production period as more reservoirs are tapped or leakage occurs between reservoirs. Formation waters may contain significant concentrations of toxic materials; i.e., cyanide, cadmium, chromium, lead and mercury (EPA, 1974). Therefore, it is concluded that formation waters represent a potential significant hazard which could degrade the water quality and which may have adverse effects on the marine biota. Injection of formation waters into depleted, producing or an unrelated formation could eliminate this effect on water quality. Table D-3 indicates the content of three representative brines (formation water) from offshore Louisiana. They are classed as formation waters containing high, average, and low solids.

Water quality could be further degraded as the result of accidental oil spills. Part of this spilled oil would be removed by clean-up operations and some would probably be dispersed into the waters of the Gulf where it will be reduced further by microbial degradation and weathering.

It is estimated (USGS, 1975) that from zero to two terminal storage facilities may be constructed onshore as a result of this proposed sale. This proposed construction may have a slight impact on the water quality in the vicinity of these facilities.

Impact on Ship Traffic and Navigation

In the Gulf of Mexico safety fairways have been established for the safe passage of vessels enroute to or from U.S. ports. Consequently, placement of rigs or platforms are prohibited within these fairways. Ships do not always use these fairways and this increases the possibility of a collision with drilling rigs, permanent platforms or vessels attending these platforms. Impacts which could result include loss of human life, spillage of oil, release of debris, including part of or the entire drilling rig and the ship. The contents of the ship's cargo could pose a serious threat to the environment if it includes toxic materials such as chemicals, crude oil or refinery products.

A marine casualty is any casualty involving a vessel other than a public vessel, if such casualty occurs upon the navigable waters of the United States, its territories or possessions, or any casualty involving a United States vessel, wherever the casualty may occur. Casualties involving commercial vessels must be reported to the U.S. Coast Guard whenever the casualty results in any of the following: actual physical damage to property in excess of $1,500; material damage affecting the seaworthiness or efficiency of a vessel; stranding or grounding; loss of life; or injury causing any person to remain incapacitated for a period in excess of 72 hours, except injury to harbor workers not resulting in death, and not resulting from vessel casualty or vessel equipment casualty.

Eight cases involving collision of vessels of over 1,000 gross tons with fixed structures were reported in the Gulf of Mexico during the period from July 1, 1962, through June 30, 1973. Twenty-two other collisions of vessels less than 1,000 gross tons with fixed structures were reported during this eleven year period. Fifteen of the accidents involved vessels less than 100 gross tons and the remaining seven vessels ranged between 100 and 650 gross tons. Of the twenty-two accidents, there was no loss of life involved and damage to the rig was insignificant (USGS, 1974).

For the period from July 1, 1973 to June 30, 1975, there were 32 collisions of vessels with fixed structures reported. Three collisions involved vessels of over 1,000 gross tons. Thirteen collisions involved vessels from 100 to 1,000 gross tons. Sixteen collisions involved vessels of less than 100 gross tons (USCG, 1976).

Figure E-1 shows the increase in the number of offshore structures versus the small number of accidents during the period 1965 through 1973 involving these platforms in the Gulf of Mexico. It should be noted that while the number of structures is increasing, the number of accidents involving structures has not increased. The accidents involving small vessels might in some cases be considered self-generating; that is, the fishing vessels could have been near the rigs due to the improved fishing around the structures, and the barges, cargo and passenger vessels could in some cases have been servicing the platforms.

The most serious environmental hazard involving offshore structures and shipping accidents would occur in the case of an oil tanker colliding with a platform. In this theoretical case, supertankers might be considered in a more favorable light than small tankers if the following were the case: The offshore terminal buoy process was used. They are known as offshore deepwater terminals or "Superports". The fairway, the area near the fairway and the area around the terminal buoy had no nearby bathymetric hazards, or these hazards were carefully surveyed and marked. The super-tankers were kept in the fairways in the area of offshore structures. The super-tanker traffic was restricted to one way traffic in the fairways so that tankers were never on head-on courses.

In summary, the possibility exists for an increased number of collisions to occur as the number of platforms increase.

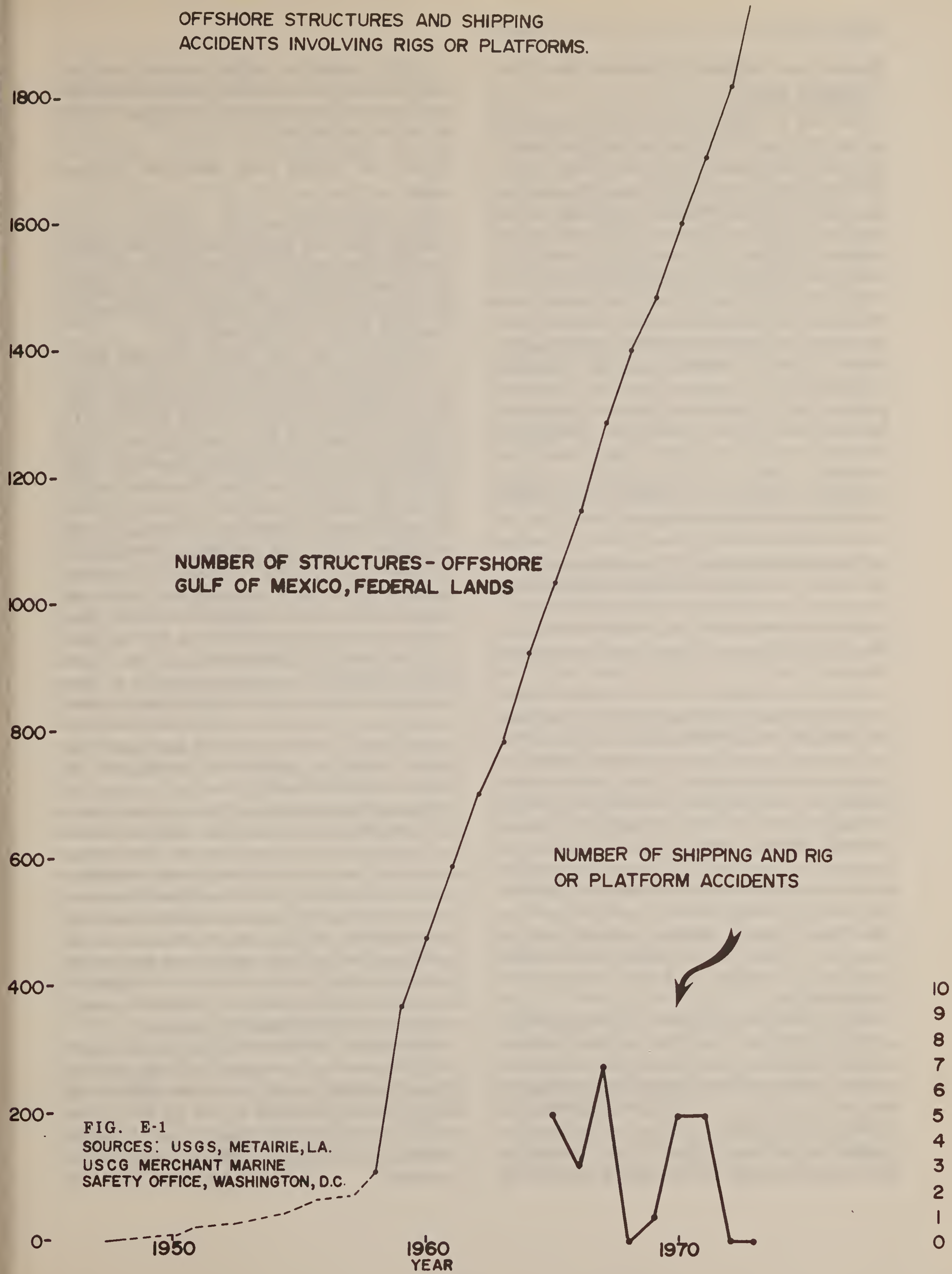


FIG. E-1
SOURCES: USGS, METAIRIE, LA.
USCG MERCHANT MARINE
SAFETY OFFICE, WASHINGTON, D.C.

Impact on Military Uses of the Continental Shelf

The Gulf of Mexico is used rather extensively by the Navy and Air Force for conducting military training and research operations. These current activities consist of missile testing, ordnance testing, drone recovery operations, electronic counter measure (ECM) activities by the Air Force and training of military personnel. Mine research activities are conducted by the Department of the Navy. Most of this activity takes place in areas designated for these purposes. Live ordnance testing by the Air Force occasionally involves emergency release of ordnance outside designated bombing areas; however, these are limited to practice bombs containing 10-pound explosive. Because Air Force procedures provide for dropping ordnance over water in the event of an emergency, which precludes the use of a designated salvo area, a potential hazard exists. Such emergencies have occurred in the past, and ordnances have been jettisoned as far shoreward as Choctawhatchee Bay. No quantification as to the amount of ordnance located in and outside the salvo areas was available. The possibility of occurrence of unexploded munitions on the ocean floor in the proposed lease sale is extremely remote.

Oil and gas operations in an ordnance disposal area are potentially hazardous. The accidental detonation of munitions during the course of oil and gas drilling or other activities, should it occur, could result in loss of life, destruction of property or creation of a potential for fire and polluting events and death or injury by concussion to marine life. At this time, we consider the probability of occurrence low because unexploded ordnances and sunken WW II vessels are detectable through magnetometer surveys and sophisticated magnetic detection devices. Also, in many cases, divers can be used to aid in locating and plotting munitions and sunken vessels on the ocean floor.

The possible use of shallow, nearshore portions of the continental shelf for ordnance disposal would prohibit full exercise of the multiple use concept common to natural resource management programs. However, it is not Department of Defense (DOD) policy to dispose of ordnance in shallow waters. Such disposal is only carried out in an extreme emergency and only when necessary for the preservation of life or saving of an aircraft and never as a routine disposal procedure. Therefore, this conflict is not anticipated should this proposed sale proceed.

Impact on Beach and Shoreline Recreation

Recreational activity on beaches and in shoreline areas can receive impacts from pipeline construction onshore, from oil spills and from the placement of onshore facilities (such as production terminals or transfer facilities) should they be located in or near a recreational area.

No pipelines are projected to be brought ashore as a result of this sale unless production results in an area remote from existing transportation facilities. If a pipeline crosses a beach area used for recreation, there will be an impact. The area of beach disturbed by construction would be fairly small (9 meters wide) and high tides following burial of the pipeline would soon serve to restore the beach terrain. Restoration of the beach would take longer, most likely requiring a storm tide or high winds to obliterate the effects of excavation. Should a pipeline enter a marsh shore there would be little beach activity affected; however, there could be long lasting visual impacts due to vegetative and drainage disturbance in the laying process. Likewise, a pipeline crossing a shore backed by forest vegetation will produce an obvious corridor which may be noticeable for many years. Physical interference with recreational activities, should a pipeline be needed, will be minimal and short-lived.

If production terminal facilities are located in or near a beach or any other area used for recreation, there will be an adverse impact from disruption during the construction phase and elimination of about 16 hectares per terminal plant for recreational uses. This latter impact would be long-term and restoration of the area, if attempted at all, would have to await the depletion of the offshore production which the plant would be designed to serve. These impacts may tend to diminish quality of the area for recreational enjoyment.

Water sports such as swimming, diving, spearfishing, underwater photography, fishing for finfish and shell fish, boating and water skiing would also be directly affected by an oil spill. These would also be affected where chronic low-level discharges have caused a degradation of the environment.

Other marine related activities such as beachcombing, shell collecting, painting, shoreline nature study, camping and sunbathing on a beach would be made much less attractive for an indeterminate period if an oil spill were to come onshore.

Removal of oil from beaches used for recreation in the area under consideration would probably involve removal of the contaminated sand and possibly replacement of the sand, if needed. The time period of clean-up in this case would depend on the extent of beach area affected. Recreational use of the area would be precluded during the time that oil covered the beach and also during the clean-up process.

The impacts of an oil spill discussed above would be more keenly felt if the recreational area involved is intensively used or considered to have unique or outstanding recreational values, such as Grand Isle State Park, Galveston and Padre Islands. Not only would the impact be felt by the recreational users of the area, but, consequently, the community of businesses whose economic well-being depends on use of their recreational resources by tourists. If an oil spill were to cover outstanding recreational beaches during the heights of the recreational season, the impact could be expected to be more severe, in that residents and tourists would not be attracted to a beach area contaminated by oil or undergoing a cleanup process, and there would be a resultant economic loss.

As a result of this proposed sale, approximately 161 kilometers of new pipeline may be needed and possibly two new onshore terminals. Location of facilities would, of course, depend upon which tracts are leased and where new production actually occurs. It is unlikely that any new pipeline land-falls or shore facilities would be needed in the central Gulf area.

Most of the tracts to be leased lie south of Louisiana, some as close to shore as five kilometers and some as far out as 161 km. Three tracts lie about 19 km east of Breton National Wildlife Refuge. Two tracts are located about 13 km east of Delta Migrating Waterfowl Refuge and Pass-a-Loutre Game and Fish Preserve. Another tract lies approximately 21 km east of Grand Isle State Park. Additional tracts are scattered along the coast within 16 km of Russel Sage, Louisiana State, Paul Rainy, and Rockefeller Wildlife Refuges, and Rutherford and Hackberry beaches and Cheniere-au-Tigre State Park.

Those tracts located south of Texas are concentrated in the east. The tract nearest a recreational facility is one located approximately 23 kilometers east of Galveston and its beaches.

Barrier islands along eastern Louisiana and the Texas coast offer considerable protection to bays and estuaries against encroachment of offshore oil spills. These barrier islands and their beaches are a major recreational resource in their own right and oil spill damage could be significant. However, where wave action is strong the effects of an oil spill should be shorter lived on the outer beaches than in the bays and estuaries.

In general, if an oil spill did reach any shore or beach area, an unquantifiable amount of recreation could be curtailed for a period of several months; however, the probability of this occurring is considered remote for the area encompassed by the proposed sale.

Impact on Aesthetic and Scenic Values

If air quality permits unlimited visibility, some portion of a 30 meter high offshore structure could be seen from the beach if it were located 27 kilometers or less from shore.

Sixteen of the tracts offered south of Louisiana are close enough to shore to permit observation of operations by someone on nearby beaches. In the Texas area, three of the tracts are near enough to shore to cause a visual impact.

The effects of visual impacts caused by the observation of structures resulting from this sale will be lessened because many offshore structures are already visible from the segments of coastline that would be affected by this sale. For example, at present there are approximately 50 structures visible from the Delta-Gulf Island NWR (Widner, 1975).

Any floating material such as debris or oil that is cast upon the beach or washed into a bay would constitute an impact upon the aesthetic values for users or owners of the area.

Even after burial of a pipeline, the remaining scars will cause an impact on the aesthetic values of the beach and associated shoreline. It is our estimation that the impact will endure for at least a year, or until sand has been redistributed by wind, tides, and rain and another growing season brings about revegetation.

Revegetation of dunes crossed by pipelines would reduce adverse effects from an aesthetic and scenic viewpoint and would decrease the

chance of destruction of the dunes by erosion. However, it is not within the Federal Government's authority to require the revegetation of affected dunes unless they are on federal lands. State or local authorities may require revegetation of dunes disrupted by pipeline installations.

It is impossible to backfill canals or ditches in marsh areas because of the unconsolidated nature of the substrate, therefore there will be an adverse impact on aesthetic values if any pipelines are constructed. The laying of a pipeline in these areas would result in an open canal or ditch through the marsh. However, this would be an add-on effect in much of the central Gulf region since there are at present numerous canals or ditches of this type.

There would be an adverse impact on aesthetic and scenic values resulting from construction of onshore terminal and produce storage facilities and pumping stations if these facilities are located in areas which are valued for their natural or scenic qualities. Some people will find the visual impact of these facilities aesthetically displeasing. There may also be noise pollution associated with vehicular traffic to and from these facilities and noise pollution resulting from pumping stations that would reduce the serene and natural qualities of an otherwise aesthetically enjoyable area.

The probability for the aforementioned impacts to occur is considered low. However, if any did occur, the duration would depend on numerous variables and the extent would be partly reflected in an individuals own values.

Impact on Conservation Resources

The impact of oil spills and pipeline and onshore facility construction on biota, air and water quality, beaches, etc. has been discussed previously. Should an oil spill occur in a conservation area, or should pipeline and onshore facility construction occur in one of these areas, the impacts discussed above will apply.

As previously mentioned, Delta National Wildlife Refuge and Pass-a-Loutre State Refuge are near two oil prone tracts. With the occurrence of onshore winds, oil spills could reach these marshes in a few hours. It should be noted that the entire Louisiana coast is bordered by leased and developed tracts and the current offering represents a small, incremental increase in oil spill risk.

Impact on Historical and Archaeological Sites, Structures and Objects

Impacts on these features could stem from two sources. During an oil spill, any objects coated with oil would obviously be rendered less useful and valuable and may not survive cleaning operations. In addition, porous items such as wood, pottery or shell may be internally contaminated with oil and this might interfere with carbon dating procedures. Undiscovered archaeological sites or objects and shipwrecks may be destroyed during drilling, pipeline burial operations, or construction of terminal, storage or pumping facilities. (See section Mitigating Measures in the Proposed Action).

Degradation of the visual surroundings of a historical site could occur if onshore facilities or offshore platforms were constructed nearby. However, petroleum related facilities are commonplace sites in the general area and so in many places would not be considered as new intrusions on the visual aesthetics of the area.

It is not likely that any National Register sites will be adversely affected by activities resulting from this sale, either oil spills or construction of onshore facilities.

Impact on Sport Fishing and Recreational Boating

Although we have no conclusive evidence, it is our opinion that a major oil spill would adversely affect sport fishing and recreational boating. Boaters and fishermen would not want to soil their boats by entering a contaminated area for the duration of the spill incident.

Aside from damage caused by oil spills, there is considerable evidence that oil and gas operations have a favorable impact on sport fishing activities. One favorable impact is the result of sports fish concentration due to the artificial reef effect on offshore platforms. In the open sea, offshore platforms provide both food and cover in areas that are largely devoid of those essentials. Myriad forms of microorganisms in the water drift by these structures and attach themselves, soon encrusting all exposed surfaces on the platform. Hard substrate is necessary for encrusting organisms: barnacles, hydroids, corals, mussels and other invertebrate organisms which serve as links in the food chain. Randall (1968) has stated that artificial reefs provide protection, food sources,

spawning sites and spatial orientation markers for fishes. The same author found that artificial reefs attract available fish from surrounding waters, and increase the size of some populations by providing additional protected areas and food for both the young and adults. The typical platform located in 30 meters of water will have a surface area of about 0.8 hectares (over 8,082 square meters) (Shinn, 1974). Other advantages of these structures is the free movement of water through and around them and their high profile. The high profile provides habitat for a wide variety of fish ranging from the turbid dark bottom zone to the lighter and clearer surface waters. Platforms are easily located by boaters and fishermen and the platforms and their personnel are a source of emergency assistance for all offshore sportsmen.

Offshore platforms are the major focus of sports divers from coastal Louisiana and may be expected to contribute significantly to the sport as their number increases in other areas of the Gulf. Divers are drawn to these structures for spear fishing, photography and general pleasure diving. The submerged portion of structures contribute to safety by assuring the divers' orientation to depth and distance (Estopinal, 1975).

It is expected that between 20 and 40 new platforms will be added as a result of this proposed sale to the more than 2055 in existence in the northern Gulf of Mexico (USGS, 1976).

Other Impacts

Induced Industrialization in the Coast Zone

Introduction

Although federal legislation influencing land use and refinery siting is presently under consideration, the federal government presently has little direct control over the spatial distribution of onshore activity induced on offshore production. This function, to the extent that it might exist, remains a state, regional or local responsibility.

The incremental and separable onshore effects attributable to this sale are difficult to identify and quantify because: (1) The proposed sale represents only a portion of a continuing activity in the coastal areas adjacent to the Gulf of Mexico. (2) The potential offshore production and onshore inducements resulting from this sale would probably coexist with interrelated, interdependent and potentially more dominant and overriding externalities such as the importation of foreign crude and the level of exploration and production activity onshore and in state waters. These activities might induce onshore responses similar to the onshore effects induced by activities on the outer continental shelf.

The quantities of crude oil and condensate currently produced from the various onshore and offshore areas have been included in the description of the petroleum industry in the Gulf of Mexico area.

Basic offshore production development assumptions

After consultation with the Geological Survey, an estimated timetable and development sequence was used to determine the projected daily and annual production rate, and other aspects of the proposed sale's impact. This timetable is shown in Table L-1 and incorporates the following assumptions:

The number of exploratory rigs utilized would increase to a maximum of 15 during the year following the sale.

After a discovery has been made, the final platform design is completed, fabrication is completed and the platforms are installed during the second to fifth year.

At this time, development drilling is started and 300 producing wells on the platforms are drilled during the next year. Platform oil, gas and water treating facilities are installed after the wells are completed. According to this schedule, the first platform is installed during the second year and the last one is installed during the fifth year. Approximately 15-20 platform rigs might be required for drilling development wells.

Production can be started approximately two years after the first discovery if pipelines are installed with the first platform. Production was then modeled to increase during subsequent years and to reach a peak rate in the fifth year.

A summary of the anticipated development scheme with estimated expenditures is shown in Tables L-2 and L-3.

Hypothetical onshore development scheme and general land use requirements

Portions of the Louisiana and Texas coasts have a developed, nearly self-contained gas and oil related infrastructure in the form of service, support, production, transportation, storage, processing, etc. facilities. The activities and facilities required by this proposed sale will therefore fall within the broad framework of similar activities and facilities in this and other proposed sales adjacent to the Gulf of Mexico.

The extent of the existing facilities in the Gulf of Mexico area have been previously described in Description of the Environment: History and Projected Economic Growth.

Table L-1 Proposed Lease Sale 44: Hypothetical Development Timetable; High Estimate

Year	Exploratory Wells	Platforms	Development Wells	Pipelines (kilometers)	Terminals
0					
1	15	0	0		
2	15	10	75	40	
3	15	1.0	75	41	
4	15	1.0	75	40	
5	15	1.0	75	40	2
Totals	75	40	300	161	2

Table L-2 The Expenditures Estimated 1/ to Result from Proposed Lease Sale 44 Range from Approximately $160 to $430 (million)

Expenditures	Low Estimate	High Estimate
1. Well drilling		
Exploratory wells	$ 25,000,000	$ 75,000,000
Development wells		
Productive	80,000,000	240,000,000
Total Well Drilling Costs	$105,000,000	$315,000.000
2. Platforms	40,000,000	30,000,000
3. Pipelines	10,000,000	20,000,000
4. Terminal/Storage Facilities	5,000,000	15,000,000
Totals	$160,000,000	$430,000,000

1/ Above table based on the following estimated costs.

Table L-2 (continued)

Exploratory well	$1,000,000
Development well	800,000
Platform	2,000,000
Terminal/Storage Facility	7,500,000
Pipeline (per mile)	150,000

Table L-3 Proposed Lease Sale 44: Annual Summary of Investment; High Estimate (in millions of dollars)

Year	Exploratory Wells	Platforms	Development Wells	Pipe-Lines	Terminals	Totals
0						
1	15.0					15.0
2	15.0	20.0	60.0	5.0	15.0	115.0
3	15.0	20.0	60.0	5.0		100.0
4	15.0	20.0	60.0	5.0		100.0
5	15.0	20.0	60.0	5.0		100.0
Totals	75.0	80.0	240.0	20.0	15.0	430.0

It is assumed that sale-induced support facilities will tend to locate in areas presently committed to and experiencing similar facilities and inducements. In general, the types and extent of existing land development are strong determinants in setting the pattern for future land development.

In particular, existing land development and activities related to the oil and gas industries are expected to be strong locational factors influencing sale related land use inducements. Areas presently committed to a highly developed gas and oil related infrastructure are expected to have a greater tendency towards, and land use precommitment to, expansion of these activities than will those areas with a low or non-existent level of development. Should new incremental requirements be induced by the proposed sale, they will essentially be an expansion of the present capabilities.

Sale inducements are generally not expected to overload this existing or historic capacity. Should the proposed sale cause incremental increases in any segment of the infrastructure, it is assumed that such increases will occur in presently industrialized areas, probably through more intense use of lands already dedicated to such uses.

Using the preceding estimates and general assumptions, the following development scheme and general land use requirements have been addressed: barging from production areas to shore; gas and oil pipeline development; oil transshipment; refinery construction, and onshore support facilities. Each of these activities has not been developed in detail because of the wide variety of economic conditions and the wide range of development alternatives available to the producers; however, the following is one realistic onshore development alternative. The estimates and land use assumptions have been developed for each major activity. These remain constant for any amount of production within broad daily ranges.

Barging from production areas to shore

Because of the anticipated production characteristics and weather constraints, no barging from production sites to onshore receiving facilities is anticipated. It has been assumed that pipelines would be installed early in the development program, and would be functional at the time of production, thus eliminating the need for this barging requirement.

Gas and oil pipeline development

The anticipated production resulting from this sale would be from tracts located offshore from the Louisiana coast and the upper coastal area of Texas. It would be necessary to install some offshore pipelines to link the new wells and production facilities to the existing offshore pipeline network. An estimated 161 kilometers of pipeline would be required for this purpose. To the extent that one of the interstate pipelines supplied from this area is currently curtailing deliveries, there should be spare onshore pipeline capacity to deliver part, if not all, of the new supplies resulting from the development to be included in this proposed sale.

Oil transshipment

It is assumed that all oil production will be pipelined to shore, stored in oil tank farms and finally transferred to existing refineries by means of existing pipelines or tanker and barge facilities.

Possible refinery construction

As discussed below, production from offshore areas will tend to offset declining onshore reserves. The total refinery and petrochemical capacities in the Texas and Louisiana coast has been and will continue to be in response to the region's need to supply crude oil and products to adjacent regions and to meet its own needs. This total will be derived independently of this proposed lease sale's possible contribution. Since this current capacity processes and will probably continue to process a combination of locally produced (onshore and offshore) and imported (domestic and foreign) crude oil, the capacity produced by this proposed sale is perceived to be inclusive of this total rather than constituting an additive factor.

The principal effect of this proposed sale on the industrial environment of the coastal areas of the Gulf of Mexico is believed to be the resulting tendency to preserve the existing industrial and economic activity in the region.

This conclusion is based on several factors, including: (a) The extensive industrial development in the area. These industries have developed over a period of many years, and have been based on existing reserves of oil and gas in the area. (b) The current decline in crude oil and condensate production in the coastal area of the Gulf of Mexico. (c) The importation of crude petroleum for refining in facilities located in the coastal zone.

The extensive existing refining capacity and petrochemical production facilities have been previously described in Description of Environment: History and Projected Economic Growth.

The extent to which crude oil and condensate produced from tracts leased as a result of this proposed sale will displace imported crude oil and condensate and will probably be dependent, in large part, on the relative price of domestic crude oil and imported crude oil.

The following comparisons are based on tables published in the January, 1976 issue of Monthly Energy Review, a publication of the Federal Energy Administration.

During March, 1975, approximately 60% of the domestic crude oil production was valued at the wellhead at $5.25 per barrel. This oil is referred to as old oil and is subject to price control. The remaining 34% of the total domestic crude oil production is referred to as uncontrolled oil and is sold at the free market price. Uncontrolled oil consists of new oil, released oil and oil produced from stripper wells. The price of new oil during October, 1975 was estimated to be $12.73 per barrel.

A preliminary estimate of the average cost for all domestic crude petroleum delivered to refiners during October was $8.59 per barrel. The refiner cost of imported crude petroleum was estimated to be $14.66 per barrel during October, 1975, or approximately $6.07 more than the refiner's average cost of domestic crude. A comparison of refiner acquisition cost of new oil with the landed cost of imported crude is difficult, due to the necessity of adding transportation costs to the wellhead price of new oil in order to arrive at a comparable cost to the refiner, but it appears probable that new domestic crude petroleum would be less costly than imported crude petroleum.

On December 22, 1975, the President signed into law the Energy Policy and Conservation Act, and at the same time removed the $2 per barrel fee on imported crude oil. Among other provisions, the Emergency Petroleum Allocation Act of 1973 has been amended to establish a composite ceiling price of $7.66 per barrel for all first sales of crude oil produced in the United States, beginning in February, 1976. The $7.66 can be increased at the discretion of the President, beginning in March, 1976, to adjust for inflation and to provide a production incentive of not more than three percent per year. However, both adjustments may not exceed 10% per year without the approval of Congress. The Act authorizes a gradual phase out of mandatory domestic price control on crude over a 40 month period.

The Federal Energy Administration (FEA, Monthly Energy Review, January, 1976) is currently preparing a program incorporating the new authorized prices applicable to newly developed oil production.

It is assumed that the additional production from tracts leased as a result of this proposed sale will displace imported crude petroleum, as well as replace the presently declining domestic crude oil production. This effect would not be anticipated to initiate an increase in refining capacity, but rather to continue the operation of the existing refineries in the Gulf of Mexico region.

Support facilities, operating bases, etc.

"Support facilities" are a wide variety of supply and service oriented industries having capabilities to support the exploration, production and transportation of gas and oil. It includes those companies dealing with tools, wireline, gas life, cement, boats, etc., as well as machine and welding shops, trucking firms, wellhead and mud suppliers, supply stores, etc. Such capability is present in many industrialized areas within the Louisiana and Texas coastal areas, and it has been assumed that capabilities exist in virtually all sectors which will be utilized by sale related demands. It is not anticipated that the proposed sale will create new demand for lands dedicated to these uses.

The individual and total sale induced acreage is assumed to be very small, and these requirements may be widely dispersed over large portions of the coastal zone. It can be assumed that the region has many sites which could host the modest acreage requirements, should development of the proposed sale be different from that assumed beforehand.

Industrial development was used as the basis for land use requirements, as its site demands are most relevent to sale related activities. However, in doing so, it is understood that this land use represents only one component of a balanced land use/population ration. New industrial development induces new employees and activities into the general sale area, and these will be distributed to

more specific areas. This suggests land use implications beyond these specifically addressed because of requirements for residential, commercial, recreational and other land use categories.

Any population or industrial inducement can be perceived as creating environmental stress for a localized area or general region. Conversely, shifting or developmental pressure to such areas can be perceived as relieving stress in other areas. Whether the result is a net gain or loss of environmental stress, is partially dependent on the relative stresses experienced in the areas which gain or lose population, and, the capability of the receiving area to accomodate new development. It is axiomatic that stress induced into an area can often be mitigated by rationally developed, goal oriented policies and land use plans. Subsequent allocation of land in response to these demands remains a responsibility of state, regional and local governments. Because of the time lag between the proposed lease sale and the resulting land use impacts, there is sufficient lead time for these entities to develop responsive land use plans and policies.

Economic Effects

The principal economic effects of the oil and gas produced as a result of this proposed sale are anticipated to be experienced in the states of Louisiana and Texas. After leasing, exploration and development activities have been completed, the exact geographic location in which economic activity will be most likely to result can be more precisely identified.

Oil and gas produced as a result of this proposed sale will become available at some time in the future, and the impact due to the economic activity resulting from this proposed sale will take place in the economic climate that exists at this time.

Currently, an increased number of rotary drilling rigs are in operation, with the total number of wells drilled during 1975 higher than the number of wells drilled during 1973 and 1974. Drilling capacity and competition for steel products may delay the development of the leases awarded as a result of this proposed sale, thereby causing a reduced annual economic effect that would otherwise be anticipated.

Although the quantities of oil and gas that may be produced from proposed Sale No. 44 are estimated to be incremental additions to the existing production of oil and gas on the Gulf of Mexico OCS, these sale related additions of 30,000 barrels of oil per day and 360 million cubic feet of gas per day would be significant.

During the month of September, 1975, crude petroleum production from the Louisiana offshore area amounted to 921,800 barrels per day, and crude petroleum production from offshore Texas amounted to 2,000 barrels per day. (USDI, 1975a).

In order for the additional quantities of oil and gas discovered as a result of proposed Sale No. 44 to become available to consumers, platforms would have to be constructed, wells would have to be drilled and pipelines linking the additional production facilities to existing transportation systems would be required.

This activity can be considered to be an extension or continuation of present employment and industrial patterns related to the existing petroleum based economy within the region.

However, some additional employment may be expected to result from the exploration, production and initial processing of crude oil and natural gas that might result from this proposed sale, and an estimate of this employment has been based on data published by the Bureau of the Census (1972).

This employment may be an addition to the work force already present in the states adjacent to the Gulf of Mexico, providing that a high level of drilling and production activity is maintained in other areas. In the event that surplus skilled labor is available within the required specialties, the impact of this proposed sale on employment in exploration and production related activities is seen to be a tendency to preserve the existing employment.

Additional employment impact, if it materializes, is anticipated to be experienced in the fields of oil and gas exploration, production and natural gas liquids treatment.

As a means of reporting employment and wage and salary payments, the Bureau of Census publishes a series of reports entitled, "1972 Census of Mineral Industries".

Data pertaining to employment in offshore oil and gas exploration and production activities during the year 1972 have been included in the section on History and Projected Economic Growth.

The data provided within MIC 72(1)-13A, Oil and Gas Field Operations, SIC 131, included tabulations of the number of offshore wells operated

during December, 1972, as well as the number of wells drilled during the year. These data are summarized on Table L-4.

During the year 1972, approximately 5,100 persons were employed in offshore drilling activity (SIC 1381) adjacent to Texas and Louisiana. A comparison of this number of employees with the number of wells drilled in this area indicates a ratio of 6.72 employees per drilled well. During the second, third, fourth and fifth year following the proposed sale, 90 wells may be drilled, indicating a potential employment increase amounting to 605 jobs during those years.

During the month of December, 1972, there were 3,041 producing oil wells and 1,629 producing gas condensate wells located off the coasts of Louisiana and Texas. An additional 2,905 oil and gas condensate wells were classified as shut in during December, 1972. The total number of oil and gas condensate wells, both producing and shut-in, amounted to 7.575 wells.

Within the industry classification of SIC 1311 (Operating oil and gas field properties) and SIC 1389 (Miscellaneous oil and gas field services), approximately 7,500 persons were engaged in offshore activities.

Based on the relationship between the number of wells and the number of employees, a ratio of one employee for each well is suggested if all wells are included, or 1.6 employees per well if only the producing wells are included. The maximum of producing wells estimated to result from this sale is 300, and this number indicates that between 300 and 480 persons would be employed during the production phase.

An alternative method of estimating employment could be based on the production—employment ratio during 1972, with the application of this ratio to the production anticipated from this proposed sale. This procedure requires the determination of an equivalence between gas and oil production. If, for simplicity purposes, a comparison of employment is made only with the production of oil, then the 1972 total Gulf of Mexico offshore oil and condensate production of 455,619,000 barrels indicates an annual production of 60,749 barrels, or 1 employee for each 166 barrels of daily production. The estimated daily production from this proposed sale is estimated to amount to 30,000 barrels per day, resulting in an estimated employment effect of 181 jobs in SIC 1311 and SIC 1381. A figure of 320 individuals employed in sale related production activities is perhaps a reasonable estimate.

Those persons employed in establishments which are primarily engaged in producing liquid hydrocarbons from oil and gas field gases are enumerated in the applicable County Business Patterns under the category of SIC 132. Specific data on the number of establishments and the number of employees were published only for the states of Louisiana and Texas, although processing plants were noted as being present in the other coastal states. This employment is summarized on Table L-5.

The ratio of employees to billion cubic feet of natural gas processed per year, based on the total natural gas processed in the states of Texas and Louisiana, is 2.78 employees per billion cubic feet processed.

The natural gas production estimated to result from this proposed sale amounts to 360 million cubic feet of gas per day, or approximately 31.4 billion cubic feet per year, indicating an employment effect of approximately 87 jobs.

Estimations of the total direct employment which will result from exploration, production and natural gas processing as a result of this proposed lease sale amounts to approximately 1,012 persons:

Category	Annual employment
Oil and gas well drilling	605
Oil and gas production	320
Natural gas liquids extraction	87
Total employment	1,012

The average taxable wages paid within these classifications was calculated from the payroll data provided in the County Business Patterns, and are expressed in 1972 dollars paid during the first quarter of that year.

Total annual wages of the 605 employees of the drilling industries would amount to approximately $5 million dollars; the annual wages of the 320 employees during the production activities would amount to approximately $3.5 million dollars, and the annual payroll of employees of the natural gas processing industry would amount to approximately $1 million dollars. The total payroll of the 1,012 employees is estimated to amount to approximately $10 million (1972 dollars).

Table L-4

1. Wells Completed in Offshore Areas (1972)

Area	Oil	Gas Condensate	Dry	Service	Total
Louisiana Offshore	232	166	299	7	704
Texas Offshore	4	20	30	0	54
Gulf of Mexico	236	186	329	7	758
California	47				
		0	3	25	79
Alaska	4				
Total Offshore	287	186	332	32	837

2. Wells Operated in Offshore Areas (December, 1972)

Area	Producing		Shut In		Total
	Oil	Gas/Cond.	Oil	Gas/Cond.	
Louisiana Offshore	3,021	1,512	2,086	741	7,360
Texas Offshore	20	117	18	60	215
Gulf Mexico	3,041	1,629	2,104	801	7,575
California	1,482	11	370	8	1,871
Alaska	113	3	12	2	130
Total Offshore	4,636	1,643	2,486	811	9,576

Source: Census of Mineral Industries (1972)

Table L-5 Number of Liquid Hydrocarbon Producing Units and Employment - 1970

State	Number of Reporting Units	Number of Employees
Louisiana	51	973
Texas	111	4,219
Totals	162	5,192
Total U. S.	255	7,320

State	Natural Gas Processed (Billion cubic feet)
Louisiana	6,337.3
Texas	8,139.3
Total	14,476.7

Source: County Business Patterns
Bureau of the Census

Persons directly employed in operations relative to the exploration and production of oil and gas can be expected to spend their wage and salary income for purchases of goods and services.

The provision of these goods and services will require the employment of other persons. The number of persons employed in support industries would be dependent on both the consumption patterns of those directly employed, as well as the extent to which labor within an economic system was engaged in the production of goods for consumption within the same system. Since a wage or salary worker would be expected to meet the largest portion of his needs within the area of his residence, the expenditure of wage and salary payments for items produced outside of the local economy would be expected to generate additional support employment in the area in which the item was produced.

The value of the wage and salary payments made to the persons employed in support activities has been determined by calculating an average wage and salary payment for the two state area from data included within the applicable County Business Patterns publications as shown in Table L-6.

The number of persons employed in support industries, or the employment induced in other sectors of the economy shown by increases of employment in basic industries has been treated in Offshore Revenue Sharing, a publication prepared by the Gulf South Research Institute of Baton Rouge, Louisiana and the Structure of the Texas Economy, prepared by Herbert W. Grubb of the Office of Information Services in March, 1973. A paper prepared by Dr. Grubb in 1972, entitled, "Economic Aspects of the Petroleum Industries of the Texas Economy" contained some data for determining the induced employment which results from oil related activities.

The economic impact of a million dollar change in output of petroleum refining is shown to be $2.56 million. This represents the direct value of output from these industries plus the indirect effects from other related industries, as well as the induced effects of the changes in income of the wage and salary earners (households) involved. Each million dollar in output of crude is estimated to employ 50 workers within the economy, of which 11 are employed directly in oil field work and 39 are employed in the support and induced industries. (Grubb, 1972). This estimate indicates that 3.5 persons are employed in support and induced industries for every person directly employed in oil field work.

In Offshore Revenue Sharing, the primary employment estimated to result from OCS activity amounted to 40,300 persons engaged in activities within the categories of mining, manufacturing, construction, chemicals and allied products and refining. The supporting employment was estimated to amount to 84,100 persons, indicating a relationship of approximately 2.08 persons employed in support industries for every person employed in the petroleum related industries.

For the purpose of estimating impact that may result from this proposed sale, employment in support industries will be based on an estimated 2.1 persons employed for every person employed in the basic oil related sectors.

Since direct employment is estimated to amount to 1,012 persons during the years of peak activity, the induced employment during these years can be estimated to amount to an additional 2,125 persons. Based on an average annual wage or salary of approximately $6,654 in 1972 dollars, estimations of total wage and salary payments will amount to approximately $14 million in 1972 dollars.

Additional employment can be anticipated as a result of the required construction of pipelines, production platforms and other facilities. It is anticipated that the economic stimulus that may result from these activities will be experienced primarily in the states of Louisiana and Texas.

Standard Industrial Classification 3533, Oil Field Machinery and Equipment, includes establishments primarily engaged in manufacturing machinery and equipment for use in oil and gas fields or for drilling water wells. This classification includes the manufactures of rock bits, derricks and rigs, drilling tools, oil and gas machinery and equipment.

The relative importance of this industry in the Gulf of Mexico area is apparent. Of a total U.S. employment of 35,915 in this industry, approximately 20,000 are employed in the state of Texas and an additional 1,607 in the state of Louisiana.

The construction and installation of fixed production platforms require by this proposed sale will probably be accomplished in existing Gulf of Mexico facilities.

The National Petroleum Council, in response to a request from the Department of the Interior, un-

Estimated Income of Persons Employed by Oil and Gas Support Industries in the Gulf of Mexico Region

Table L-6

State	Total Taxable payrolls Mid March 1972 (Thousands)	Number of Employees Mid March 1972	Taxable Payroll: per employee Per Quarter	Annual
Louisiana	$1,419,694	852,793	$1,664.75	$6,659.00
Texas	5,195,118	3,125,175	1,662.34	6,649.36
Totals	$6,614,812	3,977,968		
Two State Average			$1,663.54	$6,654.18
United States	$108,084,852	58,015,904	$1,863.02	$7,452.08

Source: County Business Patterns
Bureau of the Census

dertook a study to forecast the availability of materials, manpower and equipment necessary for exploration and production of oil. The results of this study are contained in Availability of Materials, Manpower and Equipment for the Exploration, Drilling and Production of Oil 1974-1976 (National Petroleum Council, 1974). In reference to the construction of platforms, this study concluded that the total platform requirements would be 50 platforms (150,000 tons) during 1974, 55 platforms (176,000 tons) during 1975 and 60 platforms (204,000 tons) during 1976. Contractors indicated that present yard facilities are capable of producing approximately 200,000 tons, with steel availability cited as the primary limitation to production. Present expansion plans will increase yard capabilities over the next two years so that the physical plant should not be a constraint on production through 1976.

The crude hydrocarbons produced as a result of this proposed sale will probably receive further processing within existing facilities in the Gulf of Mexico area. Facilities such as refineries, existing crude oil and natural gas gathering and transportation systems and petrochemical plants will be utilized to the maximum extent possible, and it is anticipated that additional facilities of this type will not result from this proposed sale.

In summary, it appears probable that oil and gas produced as a result of this proposed sale will provide for the continuation of existing patterns of employment in those areas adjacent to the Gulf of Mexico where the industrial infrastructure related to the oil and gas industry is established. Activities such as the construction of drilling equipment and the necessary foundation and production facilities will probably be accomplished in existing manufacturing facilities.

The impact of this proposed sale may result in a possible increase in the employment of persons directly engaged in activities related to drilling and production, and in the number of additional persons employed in secondary and tertiary support industries.

The total annual employment that may be expected from this proposed sale amounts to approximately 3,137 persons, with 1,012 persons directly employed and 2,125 persons indirectly receiving employment as a result of the expenditures of the first group. These peak employment effects would be present when drilling and production activities were being conducted simultaneously.

Among the data prepared and published by the Bureau of the Census are tables presenting the last occupation of the experienced unemployed. These data are significant in providing some insight as to the number of persons who are already present in an area that may become employed as a direct or indirect result of petroleum related activity on the outer continental shelf. Additional stress on a region may be mitigated to the extent that persons already within the area are employed, rather than additional persons migrating to the area as a consequence of OCS operations.

Table L-7 summarizes the Bureau of Census data on a statewide basis for 1970. The figures shown apply to male and female workers aged 16 years of age and older, and they also include persons who were employed most recently for the ten years prior to the 1970 census.

Table L-7 Employment Data for the Gulf of Mexico Region - 1970

Texas

Occupation	Male	Female	Total
Professional, managerial and technical	6,823	5,343	
Sales workers	3,671	6,141	
Clerical and kindred workers	4,239	18,342	
Craftsmen, foremen and kindred	17,445	ND	
Operatives, including transport	18,790	11,233	
Laborers, except farm	12,956	ND	
Farm workers	4,388	1,317	
Service workers, including private household	7,772	14,348	
Other blue collar	ND	2,585	
Service workers, except private household	ND	ND	
Private household workers	ND	4,549	
Total	76,649	66,524	143,173

Louisiana

Occupation	Male	Female	Total
Professional, managerial and technical	2,580	1,820	
Sales workers	1,043	1,891	
Clerical and kindred	1,642	5,520	
Craftsmen, foremen and kindred	9,420	ND	
Operatives, including transport	9,533	3,216	
Laborers, except farm	6,884	ND	
Farm workers	1,558	380	
Service workers, including private household	3,007	ND	
Other blue collar	ND	969	
Service workers, except private household	ND	5,126	
Private household workers	ND	3,183	
Total	35,925	23,164	59,089

Source: Bureau of the Census

Matrix Analysis of Potential Impacts on Major Resources and Activities

Purpose

The purpose of this matrix analysis is to analyze some of the potential impacts of the proposed OCS lease sale by way of a matrix analytical technique in an attempt to provide the decision-maker and reviewer with an array of factors which must be considered in order to form value judgements concerning the importance of these interactions.

In this section, each tract is included in a table designed to describe its distance from shore, water depth and expected type of production. In addition, the sensitivity of major resources and activities to impacts of oil spills, should one occur, and to impacts of structures, should the tract be developed, is evaluated by means of a sensitivity rating for both spills and structures.

Significant Resource Factors

The matrix analysis examines major resource categories which could sustain negative impacts as a result of the development of the tracts included in the proposed lease sale. Significant resource factors appear on the horizontal axis of each matrix and for purposes of this analysis have been identified to consist of:

littoral systems
reefal systems
benthic systems
endangered species
commercial and sport fishing
shipping
aesthetics
outdoor recreation
cultural resources

All evaluations of the above categories were based on measurement from the edge of the tract closest to the resource potentially affected.

Impact Producing Factors

This evaluation considers the sensitivity of significant resources and activities to the occurrence of oil spills and structures within the proposed sale area as being the primary factor. "Oil spills" in this context refers to spills of 100,000 gallons (2,381 bbls) or more (the volume designated as a major spill by the National Oil and Hazardous Substances Pollution Contingency Plan), and structures include platforms or other fixed structures and artificial islands.

Other impact-producing factors, such as debris resulting from drilling activities, and pipeline construction, cannot be analyzed on a tract-by-tract basis, and therefore, are not included in this matrix section. However, these and other related factors were discussed on the basis of this proposed sale in the Environmental Impact of the Proposed Sale Section.

Sensitivity Rating

Each tract has been assigned sensitivity values for oil spills and structures based primarily on the distance from a particular resource.

A series of scales have been devised for the purpose of assigning a range of values to indicate sensitivity to each impact-producing factor. These scales are presented below and consist of three levels of potential magnitude of impact..

3—Maximal potential impact
2—Moderate potential impact
1—Minimal potential impact

The judgement of the importance of any specific impact is at the discretion of the decisionmaker or reviewer.

Structures

An estimate of the importance of the impact of structures on the environment consist of two factors: quantity-in this case, it is estimated that all tracts 2,023 hectares or more in size will average two structures per tract, even though some tracts may never be developed, and time-all structures will remain on site for an average period of fifteen to twenty years.

Structures are considered to be potentially negative impacts to four of the significant resource factors mentioned previously: reefal systems, commercial and sport fishing, shipping and aesthetics.

Reefal systems containing coral and associated organisms are very sensitive to disturbances such as the turbidity created by the discharge of drill muds and cuttings. Also, nektonic population distribution may be affected by the presence of a structure. Therefore, the sensitivity ratings for reefal systems reflects these considerations and is purposely conservative due to our lack of information with regard to the distribution of drill muds and cuttings under operational conditions in marine systems.

Structures interfere with commercial fishing by removing trawling and purse seining areas. Approximately 70 percent of the catch by these two methods in the Gulf of Mexico is shoreward of the 20 meter isobath. The remainder of the catch

by these methods is concentrated between the 20 meter and the 200 meter isobath with only nominal effort expended beyond these depths.

Structures pose a collision hazard to shipping and boating in general but are especially hazardous when placed near fairways or anchorage areas and are rated accordingly.

The aesthetic sensitivity ratings are based on the visibility from sea level of a 110 foot tall structure. Within 10 miles of shore, such a structure would be obvious, whereas 11 to 15 miles from shore the structure would be hardly visible and greater than 15 miles from shore the aesthetic impact would be negligible except from the point of view of the boating community.

The above considerations resulted in the following sensitivity rating for structures:

Structures

Reefal systems
- 3—one mile or less from known reef
- 2—one to three miles from known reef
- 1—greater than three miles from known reef

Commercial fishing
- 3—within 20 meter depth contour
- 2—within 200 meter depth contour
- 1—outside 200 meter depth contour

Shipping
- 3—within 1 mile of fairway or anchorage
- 2—1 to 3 miles of fairway or anchorage
- 1—greater than 3 miles from fairway or anchorage

Aesthetics
- 3—within 10 miles of shore
- 2—11 to 15 miles from shore
- 1—greater than 15 miles from shore

OIL SPILLS

The same two factors for estimating the importance of oil spills on the environment are as follows: quantity—our analysis is based on all spills of 100,000 gallons or more (2,381 bbls), and time—the toxicity of oil is known to decrease with weathering time which depends on the rate of travel of an oil slick. For analytical purposes, we have assumed a rate of 0.5 knots which for weathering times of 24, 48 and 72 hours gives impact zones of 12, 24, and 36 nautical miles. Using toxicity at 24 hours as a base, laboratory bioassays indicate a decrease in toxicity by a factor of 0.90 for 48 hour weathering and 0.54 for 72 hours weathering (R. P. Hannah, personal communication). Therefore, assigned sensitivity values of biological systems are adjusted for distance from a potential spill site by the appropriate weathering factor.

Oil spills are considered to be potentially damaging to all of the previously listed resource factors except shipping.

If a spill were to occur within 10 miles of any resource, it probably could not be effectively contained before contacting the resources. For this reason, the highest sensitivity rating was established for 10 miles or less from littoral systems, reefal systems, endangered species, aesthetics, outdoor recreation and cultural resources. Within 11 to 20 miles the probability that oil would contact a resource is sufficient enough to warrant concern. Beyond 20 miles the possibility of contact still exists but is considered to be minimal.

The sensitivity ratings for benthic systems and sport and commercial fishing is based upon depths to which oil can be expected to be entrained in the Gulf of Mexico. In nearshore areas 10 meters or less in depth, a spill will almost certainly contact bottom sediments increasing the potential for damage to benthic systems and tainting of demersal fish species. Under extreme conditions of mixing energy, the depth to which oil might be entrained can be assumed to be 20 meters or less. Sediments at depths greater than 20 meters have little chance of being contaminated with the exception of the immediate vicinity of the spill site.

Based on the above assumptions the sensitivity scale for oil spills was developed (Table M-1).

Summary of Matrix Analysis

The matrix presents the impact of structures and oil spills upon applicable resources and activities based on the sensitivity scales and in the case of oil spills weathering as it applies to potential impact upon living resources (See Matrix Analysis Table M-2).

Impact upon individual resource categories are totaled resulting in a cumulative impact. This is divided by the total possible resulting in an impact index. For example, tract number three has a cumulative impact for structures of eight out of 12 possible for an impact index of .67 for structures. The same tract has a cumulative impact rating of 15 for oil spills out of a total possible of 24 for an impact index of .63. These are summed for an additive impact of 1.30.

The impact index and additive impact ratings can be evaluated as follows:

Impact Index
- 1.00-0.78 Maximal potential impact
- 0.77-0.56 Moderate potential impact

0.55–0.33 Minimal potential impact

Additive Impact

2.00–1.44 Maximal potential impact

1.43–0.89 Moderate potential impact

0.88–0.33 Minimal potential impact

Table M-1 Oil Spills

Littoral system
- 3 - within 10 miles of shore
- 2 - 11-20 miles from shore
- 1 - greater than 20 miles from shore.

Reefal system
- 3 - within 10 miles of reef
- 2 - 11-20 miles from reef
- 1 - greater than 20 miles from reef

Benthic system
- 3 - 10 meters depth or less
- 2 - 11-20 meters depth
- 1 - greater than 20 meters depth

Endangered species
- 3 - within 10 miles of known habitat
- 2 - 11-20 miles from known habitat
- 1 - greater than 20 miles from known habitat

Sport and Commercial fishing
- 3 - 10 meters depth or less
- 2 - 11-20 meters depth
- 1 - greater than 20 meters depth

Aesthetics
- 3 - within 10 miles of shore
- 2 - 11-20 miles from shore
- 1 - greater than 20 miles from shore

Outdoor recreation
- 3 - within 10 miles of shore
- 2 - 11-20 miles from shore
- 1 - greater than 20 miles from shore

Cultural resources
- 3 - within 10 miles of shore
- 2 - 11-20 miles from shore
- 1 - greater than 20 miles from shore

Lease area identification:

BS - Brazos - South Addition
G - Galveston
HI - High Island
HIE - High Island - East Addition
HES - High Island - East Addition - South Extension
WC - West Cameron
WCS - West Cameron - South Addition
ECS - East Cameron - South Addition
V - Vermilion
VS - Vermilion - South Addition
SMI - South Marsh Island
SMS - South Marsh Island - South Addition
SMN - South Marsh Island - North Addition
EI - Eugene Island
EIS - Eugene Island - South Addition
SS - Ship Shoal
ST - South Timbalier
WD - West Delta
SP - South Pass
MP - Main Pass
MSE - Main Pass - South & East Addition
MS2 - Mobile South No. 2

Code for abbreviations on matrix tables:

G - Gas prone tract
O&G - Oil and gas prone tract
O - Oil prone tract
NA - Not Applicable
/ - Upper portion of each block pertains to impact from structures, lower portion pertains to impacts from possible oil spills.

Table M-2. Matrix Analysis Table

TRACT DATA				RESOURCES AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location 1/	Distance from Shore (miles)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Reefal Systems	Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
1 BS A-104	22	57	G	NA	1	NA	NA	2	2	1	NA	NA	6	0.50	0.50
2 G 144	11	14	G	NA	1	NA	NA	3	3	2	NA	NA	9	0.75	0.75
3 HI 109	14	14	O&G	NA / 2	1 / 1	NA / 2	NA / 2	3 / 2	2 / NA	2 / 2	NA / 2	NA / 2	8 / 15	0.67 / 0.63	1.30
4 HI 141	15	15	G	NA	1	NA	NA	3	3	2	NA	NA	9	0.75	0.75
5 HIE A-228	34	27	G	NA	1	NA	NA	2	3	1	NA	NA	7	0.58	0.58
6 HES A-281	44	52	G	NA	1	NA	NA	2	1	1	NA	NA	5	0.42	0.42

1/ Tract designations in the matrix analysis table are listed by tract number followed by the lease block location. Appendix A presents a detailed description of each tract.

Table M-2 (continued)

TRACT DATA				RESOURCES AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (miles)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Reefal Systems	Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
7 HES A-310	50	64	G	NA	1	NA	NA	2	1	1	NA	NA	5	0.42	0.42
8 WC 69	9	11	G	NA	1	NA	NA	3	1	3	NA	NA	8	0.67	0.67
9 WC 103	12	12	G	NA	1	NA	NA	3	1	2	NA	NA	7	0.58	0.58
10 WC 134	18	12	G	NA	1	NA	NA	3	1	1	NA	NA	6	0.50	0.50
11 WC 170	22	11	G	NA	1	NA	NA	2	1	1	NA	NA	5	0.42	0.50
12 WC 264	42	24	G	NA		NA	NA				NA	NA			0.42

Table M-2 (continued)

TRACT DATA				RESOURCES AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (miles)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Reefal Systems	Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
13 WC 270	48	27	G	NA	1	NA	NA	2	1	1	NA	NA	5	0.42	0.42
14 WCS 455	67	36	G	NA	1	NA	NA	2	2	1	NA	NA	6	0.50	0.50
15 WCS 459	64	39	G	NA	1	NA	NA	2	2	1	NA	NA	6	0.50	0.50
16 WCS 460	71	39	G	NA	1	NA	NA	2	3	1	NA	NA	7	0.58	0.58
17 WCS 506	77	43	G	NA	1	NA	NA	2	3	1	NA	NA	7	0.58	0.58
18 WCS 507	79	46	G	NA	1	NA	NA	2	3	1	NA	NA	7	0.58	0.58

Table M-2 (continued)

TRACT DATA				RESOURCES AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (miles)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Reefal Systems	Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
19 WCS 528	90	54	G	NA	1	NA	NA	2	3	1	NA	NA	7	0.58	0.58
20 WCS 539	98	75	G	NA	1	NA	NA	2	1	1	NA	NA	5	0.42	0.42
21 WCS 601	109	78	G	NA	1	NA	NA	2	1	1	NA	NA	5	0.42	0.42
22 ECS 333	100	75	G	NA	1	NA	NA	2	3	1	NA	NA	7	0.58	0.58
23 ECS 336	103	78	G	NA	1	NA	NA	2	2	1	NA	NA	6	0.50	0.50
24 ECS 340	101	78	G	NA	1	NA	NA	2	3	1	NA	NA	7	0.58	0.58

Table M-2 (continued)

TRACT DATA				RESOURCES AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (miles)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Reefal Systems	Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
25 V 25	5	8	G	NA	1	NA	NA	3	1	3	NA	NA	8	0.67	0.67
26 U 37	7	11	G	NA	1	NA	NA	3	1	3	NA	NA	8	0.67	0.67
27 V 50	8	5	G	NA	1	NA	NA	3	2	3	NA	NA	9	0.75	0.75
28 U 102	24	20	G	NA	1	NA	NA	3	1	1	NA	NA	6	0.50	0.50
29 V 146	32	24	G	NA	1	NA	NA	2	1	1	NA	NA	5	0.42	0.42
30 V 156	34	25	G	NA	1	NA	NA	2	1	1	NA	NA	5	0.42	0.42

Table M-2 (continued)

TRACT DATA				RESOURCES AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (miles)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Reefal Systems	Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
31 U 160	35	27	G	NA	1	NA	NA	2	1 / NA	1	NA	NA	5	0.42	0.42
32 U 163	38	28	G	NA	1	NA	NA	2	1 / NA	1	NA	NA	5	0.42	0.42
33 US 277	76	55	G	NA	1	NA	NA	2	1 / NA	1	NA	NA	5	0.42	0.42
34 US 286	78	57	G	NA	2	NA	NA	2	1 / NA	1	NA	NA	6	0.50	0.50
35 US 310	83	63	G	NA	1	NA	NA	2	1 / NA	1	NA	NA	5	0.42	0.42
36 SMI 8	30	20	O&G	NA / 0.90	1 / 0.90	NA / 1.80	NA / 0.90	3 / 2	1 / NA	1 / 1	NA / 1	NA / 1	6 / 9.5	0.50 / 0.40	0.90

Table M-2 (continued)

TRACT DATA				RESOURCES AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (miles)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Reefal Systems	Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
37 SMS 183	98	114	G	NA	3	NA	NA	1	1 / NA	1	NA	NA	6	0.50	0.50
38 SMN 273	27	12	G	NA	1	NA	NA	3	1 / NA	1	NA	NA	6	0.50	0.50
39 SMN 276	32	15	G	NA	1	NA	NA	3	1 / NA	1	NA	NA	6	0.50	0.50
40 EI 37	3	3	G	NA	1	NA	NA	3	2 / NA	3	NA	NA	9	0.75	0.75
41 EI 229	40	37	G	NA	1	NA	NA	2	1 / NA	1	NA	NA	5	0.42	0.42
42 EIS 301	62	61	G	NA	1	NA	NA	2	1 / NA	1	NA	NA	5	0.42	0.42

Table M-2 (continued)

TRACT DATA				RESOURCES AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (miles)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Reefal Systems	Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
43 EIS 302	62	67	G	NA	1	NA	NA	2	1	1	NA	NA	5	0.42	0.42
44 EIS 310	62	68	O&G	NA / 0.54	1 / 0.54	NA / 0.54	NA / 0.54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	5 / 6.2	0.42 / 0.26	0.68
45 EIS 311	70	67	O&G	NA / 0.54	1 / 0.54	NA / 0.54	NA / 0.54	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	5 / 6.2	0.42 / 0.26	0.68
46 EIS 351	72	90	G	NA	1	NA	NA	2	1	1	NA	NA	5	0.42	0.42
47 EIS 352	72	86	G	NA	1	NA	NA	2	1	1	NA	NA	5	0.42	0.42
48 SS 15	3	3	G	NA	1	NA	NA	3	1	3	NA	NA	8	0.67	0.67

TRACT DATA				RESOURCES AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (miles)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Reefal Systems	Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
49 SS 36	3	3	G	NA	1	NA	NA	3	1 / NA	3	NA	NA	8	0.67	0.67
50 SS 111	17	10	G	NA	1	NA	NA	3	1 / NA	1	NA	NA	6	0.50	0.50
51 SS 213	32	33	O&G	NA / 0.90	1 / 0.90	NA / 0.90	NA / 0.90	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	5 / 7.6	0.42 / 0.32	0.74
52 SS 232	34	38	O&G	NA / 0.90	1 / 0.90	NA / 0.90	NA / 0.90	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	5 / 7.6	0.42 / 0.32	0.74
53 ST 182	33	38	O&G	NA / 0.90	1 / 3	NA / 0.90	NA / 0.90	2 / 1	1 / NA	1 / 1	NA / 1	NA / 1	5 / 9.7	0.42 / 0.40	0.82
54 WD 34	10	18	O&G	NA / 3	1 / 1	NA / 2	NA / 3	3 / 2	1 / NA	3 / 3	NA / 3	NA / 3	8 / 20	0.67 / 0.83	1.50

Table M-2 (continued)

TRACT DATA					RESOURCES AND ACTIVITIES									IMPACT		
Tract Number	Lease Block Location	Distance from Shore (miles)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Reefal Systems	Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
55	WD 47	10	13	O&G	NA / 3	1 / 1	NA / 2	NA / 1	3 / 2	1 / NA	3 / 3	NA / 3	NA / 3	8 / 18	0.67 / 0.75	1.42
56	SP 57	4	55	O	NA / 3	1 / 1	NA / 1	NA / 1	1 / 1	3 / NA	3 / 3	NA / 3	NA / 3	8 / 16	0.67 / 0.67	1.34
57	MP 72,74	5	36	O	NA / 3	1 / 1	NA / 1	NA / 1	3 / 1	3 / NA	3 / 3	NA / 3	NA / 3	10 / 16	0.83 / 0.67	1.50
58	MP 114	11	16	G	NA	1	NA	NA	3	3 / NA	2	NA	NA	9	0.75	0.75
59	MP 116	11	15	G	NA	1	NA	NA	3	3 / NA	2	NA	NA	9	0.75	0.75
60	MSE 160	21	37	G	NA	1	NA	NA	2	2 / NA	1	NA	NA	6	0.50	0.50

TRACT DATA				RESOURCES AND ACTIVITIES									IMPACT		
Tract Number Lease Block Location	Distance from Shore (miles)	Approximate Depth (meters)	Estimated Type of Production	Littoral Systems	Reefal Systems	Benthic Systems	Endangered Species	Sport and Commercial Fishing	Shipping	Aesthetics	Outdoor Recreation	Cultural Resources	Cumulative Impact	Impact Index	Additive Impact
61 MS2 N658 E 47	31	200	G	NA	3	NA	NA	1	1	1	NA	NA	6	0.50	0.50
				NA		NA	NA				NA	NA			
				NA		NA	NA				NA	NA			
				NA		NA	NA				NA	NA			
				NA		NA	NA				NA	NA			
				NA		NA	NA				NA	NA			

Cumulative Impact of the Proposed Sale and Other Federal Actions

An Additional Gulf of Mexico OCS Oil and Gas Lease Sale

The proposed action is a part of a program to accelerate oil and gas leasing on the Outer Continental Shelf. The proposed OCS Planning Schedule, released in June 1975 (Figure F-1), lists an additional OCS sale in the Gulf of Mexico (Proposed Sale No. 47). The effect of another sale in addition to this proposed sale would be to increase oil and gas operation activity, increase peak activity levels, and generally extend the peak activity period and the timeframe anticipated for this proposed sale. The number and amount of certain activities or substances introduced into the environment as a result of oil and gas activities would be additive in nature, such as number of platforms, drill cuttings disposed, and drilling muds released into the marine environment. Possibilities of oil spills resulting from blowouts would increase since blowout probabilities are a function of the number of wells.

During the past years, several oil and gas lease sales have been held in the Gulf of Mexico and production from these sales represents a significant portion of the Nation's current oil and gas production. The effect of this proposed sale is seen as a continuation of the existing oil and gas production in the Gulf of Mexico region, and the possible continued use of existing facilities established in response to production developed from past onshore and offshore activities. Through January 1, 1975, approximately 15,500 wells had been drilled offshore in the Gulf of Mexico, including 3,997 exploratory wells and 11,503 development wells (API, Basic Petroleum Data Book, 1975).

Since economies of scale could be achieved in some areas, certain activities would not increase in number or amount proportional to the increase in acreage leased or minerals extracted. Onshore support bases and pipelines, depending on the timing and success of additional operations, might require only marginal augmentation.

Two different types of impact associated with the varying levels of activity would result from an additional Gulf of Mexico sale. Some impacts would be additive in nature, such as the amount of acreage devoted to platform use. Other impacts would be expected in the nature of maintenance of an existing level of activity. For example, the types and magnitude of economic activity expected to result from this proposed sale are not believed to be great enough to stimulate substantial increases in population and economic activity in some shore counties in which primary support facilities might be located. An additional sale and higher levels of production may stimulate enough activity in some sectors of the economy to result in more sustained levels of population and economic activity in localized areas. An additional basis for industrial location decisions would be provided by additional quantities of oil and gas adding to the possibility of greater and/or sustained economic activity.

It is more difficult to anticipate possible cumulative impacts to marine organisms. An extreme example of cumulative impacts to biological systems would be in a case in which threshold levels were reached by one action. For example, if the amount of chronic oil pollution or other effects of activities resulting from a single safe (possibly in combination with other factors) were enough to reduce a population to a critical level, then any incremental activity could be expected to result in the destruction of that population. However, understanding of the complex relationships of the various living and nonliving components of the marine environment and the effects of OCS oil and gas development on them are not, in general, sufficient to allow identification of the cumulative impact of additional sales. Even on a sale-specific basis, the identification, and especially the quantification of these impacts cannot be made with absoute certainty.

The cumulative impact of OCS lease sales in other regions has been addressed in the Final Environmental Impact Statement on the Proposed Increase in Acreage to be Offered for Oil and Gas Leasing on the Outer Continental Shelf, released by the Bureau of Land Management in July 1975.

Deepwater Ports

Deepwater port proposals have been put forth for the Gulf of Mexico including one off the coast of Louisiana and another off the coast of Texas. The Department of Transportation, the responsible Federal agency, receives permit applications for deepwater ports.

The extent to which effects of a deepwater port operating concurrently with OCS oil and gas leasing activities would be cumulative in nature would

depend in part on whether such a port is built to accommodate existing crude imports. To a larger extent, the provision of expanded refining capacity and associated deepwater ports would be a function of demand, market location, and transportation economics. If deepwater ports in the Gulf of Mexico result in a higher volume of crude transported and a higher volume of associated spills, then cumulative oil-related impacts to marine and coastal organisms could be expected. The extent and nature of these impacts would depend on the location of the port(s), any new refineries, and OCS-related facilities.

It has been suggested that oil and/or gas from the OCS might be transported to shore through the same pipeline(s) serving a deepwater port. There is no provision for this in existing legislation, and as yet it is unclear whether this would be possible. Existing legislation is administered by the Department of Transportation.

More information regarding the impacts of deepwater ports may be found in the Department of the Interior's Environmental Impact Statement on Deepwater Ports issued June 1973.

Ocean Dumping

The use of designated or interim ocean dumpsites will continue through the beginning of the next decade at which time EPA plans to phase out this practice. Given the anticipated level and timing of OCS related operations, ocean dumping would be occurring during the exploration and development phase(s). Cumulative impacts would result from pollution loadings and increased marine traffic. Increased numbers of vessels passing through dumping grounds could result in increased vessel-vessel accidents though the chances for oil spills are remote. The amount of drill cuttings, accidentally released drilling muds, and resuspended sediments caused by potential pipeline emplacement would be additive to the amounts of material disposed of by ocean dumping, and would add to the total sediment load in the ocean. Of this total, only a small fraction of the drilling mud introduced into the marine environment, or possibly the polluted, resuspended sediments (from pipeline burial) could have a cumulative negative impact on marine organisms when added to the loadings caused by ocean dumping.

Additional consideration of specific factors has been included in this Impact Statement in the section entitled, "Environmental Impacts of the Proposed Action."

MITIGATING MEASURES INCLUDED IN THE PROPOSED ACTION

The following discussion concerns the mitigatory measures which will reduce possible adverse impacts that could result from this proposed sale. These measures are presented as they relate to oil spills, offshore structures and pipelines as well as other impact-producing activities associated with OCS oil and gas development.

Oil Spills

Regulations

Regulations governing OCS oil and gas lease operations in the Gulf of Mexico are contained in Title 30, Code of Federal Regulations and OCS Orders Nos. 1, 3, 4, 6, 7, dated August 28, 1969, No. 2 dated January 1, 1975, No. 5 dated June 5, 1972, Nos. 8-9, dated October 20, 1970, No. 11 dated January 1, 1975, No. 12 dated February 1, 1975, and No. 13 effective October 1, 1975 (Appendix B). Leasing regulations are contained in Title 43, Code of Federal Regulations. The regulations established procedures and requirements to be followed in all stages of lease operations: exploration and development, drilling, production, transportation (pipeline construction and operation) and abandonment.

A general description of operating requirements under the existing regulations follows:

Plans

Operating plans must be submitted by the operators and approved by the Geological Survey (USGS) before each stage of operations is initiated (exploration, development and abandonment). Approval of all operations must be obtained prior to their commencement.

Operator inspection and testing

The operator is required to inspect all aspects of the safety systems at specific intervals, e.g., daily pollution inspection on manned facilities, ''frequent'' inspection on unmanned facilities and a monthly test of check valves. Detailed records of inspections and tests are required.

Reports

The operator is required to report all spills or leakage of oil to USGS without delay. He is also required to notify the Geological Survey of any unusual conditions, problem or malfunction within 24 hours. (30 CFR 250.45)

Safety devices

Required safety devices include subsurface safety devices, high-low pressure shut-in controls, high liquid level shut-in controls, pressure relief valves, automatic fail-close valves at the well head, automatic fire fighting systems, automatic gas detector and alarm systems, and other safety devices on production equipment; high-low pressure sensing devices and automatic shut-in valves on pipelines; and blowout preventers, related well control equipment and mud system monitoring equipment on drilling wells.

Waste disposal

The lessee is prohibited from disposing into the ocean any oil (except that oil in produced formation water must average no more than 50 ppm, OCS Order No. 8, 2.A.5) untreated waste material or other materials which may be harmful to aquatic life or wildlife. Any drilling mud which may contain toxic substances must be neutralized before it can be disposed of in the ocean. Drill cuttings which are predominantly sand and shale must be processed, and oil must be removed before they can be disposed of in the ocean. Waste disposal must comply with the 1972 Amendment of the Federal Water Pollution Control Act. Permits for disposal must be obtained from EPA under the National Pollutant Discharge Elimination System. Sewage samples shall be collected semi-annually by lessee personnel and the samples submitted to a laboratory for analysis. Results of the analysis will be available on the platforms and rigs for inspection by the USGS technicians. Geological Survey personnel are responsible for enforcing the requirements but do not take the samples.

Site clearance

When an installation is no longer needed for development of the lease, the well is plugged with cement and all casing and piling must be severed and removed to at least 5 meters below the ocean floor and the location must be dragged to clear the site of any obstruction.

Debris

Regulations and OCS Orders prohibit the disposal of debris into the Gulf of Mexico. Solid waste must be either incinerated or transported to shore for disposal in accordance with applicable requirements under State and Federal law.

Contingency plans and equipment

The operator is required to have an approved plan for controlling and removing pollution. This includes standby pollution control equipment, in-

cluding containment booms, skimming apparatus and approved chemical dispersants immediately available to the operator at a land based location.

The Oil and Hazardous Substances Pollution Contingency Plan for the Gulf Coast Region is operative and has recently been received and updated to agree with the National Plan. In addition, the Coast Guard has established the Gulf Coast Team of the National Strike Force (NSF) at the NASA Mississippi Test Facility, Bay St. Louis, Mississippi for the purpose of responding to oil spills in the Gulf of Mexico. The National Strike Force has been established in accordance with the Federal Water Pollution Control Act and the National Oil and Hazardous Substances Contingency Plan. This team is capable of responding to incidents within two hours of notification by the appropriate District Commander.

Inspection

Evidence of compliance with the regulations and lease requirements is obtained through surveillance of the operations under the lease and enforcement of specific requirements. The inspection system of the Geological Survey includes: review and approval of plans before each operating stage is initiated; close review and follow-up as necessary, by USGS inspectors, of all reports required of the operator by the regulations and orders; on-site inspection and aerial monitoring through the use of helicopters (operators are also required to inform each other of oil spills or other irregularities which they observe).

Operators reports

A comprehensive reporting system covering all oil spills and any unusual conditions (for example, reporting and investigation of a persistent oil slick from an unknown source such as a sunken ship or natural oil seep) is required by the orders and is a key factor in monitoring operations. Operators are also required to maintain records for periodic tests of safety equipment. Approximately 275 on-site inspections of pollution incidents reported by operators were made during 1973, 1974, and 1975.

On-site inspections

During the course of drilling, all operations are inspected at least one time. Leases in certain areas or in a particular development stage may require more inspections to assure the achievement of safety objectives. Geological Survey is continuing the systematic inspection program and a more stringent enforcement policy. This has resulted in increased operator compliance along with greater coverage of production operation and better documentation of inspection results.

A complete drilling inspection is normally conducted on each drilling rig approximately every four weeks. However, random inspections may be made more frequently. Depending on the number of drilling rigs in each district, the frequency of inspections on a rig may vary from eight to fourteen per year. All producing platforms are inspected at least once a year and random inspections are made more frequently on some. The frequency rate for platform inspections is approximately one every six months.

The total number of warnings issued and suspensions ordered for infractions of OCS Orders which occurred during normal daily inspections from December 1, 1972 through January 31, 1976 are as follows:

Warnings:	
Drilling	74
Workover	17
Production	5,647
Suspensions:	
Drilling	50
Workover	6
Production	4,126

During the period of July 1, 1975 through January 31, 1976 there were four significant oil spills of more than 15 barrels reported which are described below:

While a drilling rig was taking on diesel fuel from a supply boat the rig fuel tank overflowed through the vent line spilling 20 barrels. The control room operator on loading fuel had not been attentive enough to his gauges.

The Anchor Ship was pulling an anchor in close to the Drillship. Rough seas caused the anchor to knock a hole in the Drillship fuel tank spilling 100 barrels.

Vibration caused a gasket to blow out of a flange on the discharge side of an oil transfer pump. Twenty (20) barrels of oil were spilled.

Lightning struck a production platform during an electrical storm causing a shut-in of all wells. The safety valve on one well failed to completely shut off flow and 15 barrels were spilled.

In accord with prescribed inspection procedures, Geological Survey personnel verified that remedial action had been taken in all of the above incidents prior to the reactivation of the production facilities.

A program of intensive inspections is used on OCS leasing. Inspections are conducted on a regular basis with emphasis placed on operations. Periodically, all available inspectors devote a week to a special inspection, where production platforms and drilling wells are inspected on a random basis. The Geological Survey inspector force in the Gulf of Mexico has increased from seven technicians and five engineers as of July 1, 1969, to 42 technicians and 17 engineers as of January 31, 1976. During the period November 1, 1972 through January 31, 1976 technicians spent 15,130 inspection days or 133,025 man-hours, and engineers 1,546 inspection days or 13,556 man-hours in the field. Detailed inspections were conducted on 4,444 major producing platforms and 3,063 minor platforms in the Gulf of Mexico from December 1, 1972 through January 31, 1976. Also, during this time period, 2,598 inspections of single-wells or satellites were made by boat, approximately 60% of these inspections were unannounced. Included in these inspections were 48,105 well completions. Also, during this time period, 5,071 inspections of drilling rigs were conducted. Data are not readily available on the significance of these data per reporting period. However, it is apparent that inspections have increased considerably per period since 1972.

Minor incidents of non-compliance result in formal warnings while incidents of non-compliance of a potentially more hazardous nature result in well or platform shut-ins until the operation is in full compliance with regulations and orders.

Tables A-1, A-2 and A-3 indicate equipment malfunctions detected during inspection and enforcement actions over three separate periods. These data include only the results of special inspections and are limited to the most frequent malfunctions detected.

These tables indicate specific items found to be in non-compliance during special inspections. Basic pollution control items or production equipment in which malfunctions were detected for the time period are identified. Listed in the third column are the number of items which did not operate within acceptable tolerances. These items did not fail or cause an undesirable event.

Velocity type subsurface safety valves are periodically pulled from the wells and checked. This requires removing the valve from the well for inspection, repair, adjustment, and reinstallations. One company utilized test stands to test the valve performance characteristics under simulated flow and pressure conditions. Surface operated subsurface safety valves are tested in place by releasing hydraulic pressure within the closed system thereby closing the valve; subsequently, the valve is reopened by repressuring the system. An average reporting period from February through April 1975 resulted in approximately 3,000 subsurface safety valves being checked. Of this amount, 174 failed components were detected in the valves, with a number of the valves having more than one failed component.

Nine companies were fined a total of $2,358,000 in District Court for failure to install subsurface safety devices in offshore oil wells during 1970 in the Gulf of Mexico.

Aerial monitoring

"Fly-overs" of the OCS operating areas are programmed on a seven day week basis by the Geological Survey. Any indications of oil pollution or other non-compliance is followed immediately by an on-site inspection.

During the period January 1, 1973 through January 31, 1976, 7,357 pollution surveillance flights were made. The helicopters chartered for use by the inspection personnel flew a total of 21,552 hours. No data are readily available which indicate the effectiveness of this program.

Enforcement

The enforcement policy is intended to reduce the frequency of non-compliance with lease requirements which may lead to loss of life or property or damage to the environment, and to maintain uniform enforcement standard application to all operations affecting OCS lands in the Gulf of Mexico. However, more intensive inspection has been provided to operations in the frontier areas of the Gulf of Mexico, including the MAFLA and South Texas OCS areas. When, in the course of an inspection, a requirement pertaining to the prevention of oil pollution or any other safety hazard is found to be in non-compliance, the operation will be shut-in until it is brought into compliance. After shut-in, the operation can only be resumed by authorization from the Geological Survey; in all cases, this requires reinspection or a waiver of the inspection requirement. Minor incidents of non-compliance may require only a warning that corrections be made within a week. The operations will be shut-in if the required corrections are not made.

Additional penalties for non-compliance are specific in P. L. 83-212, Outer Continental Shelf Lands Act, Sec. 5(a)(2). "Any persons who knowingly and willfully violates any rule or regulation prescribed by the Secretary for the prevention of waste, the conservation of the natural resources, or the protection of correlative rights shall be deemed guilty of a misdemeanor and punishable by a fine of not more than $2,000 or by imprisonment, and each day of violation shall be deemed to be a separate offense."

Also Sec. 5(b) (1) and (2) provide for cancellation of non-producing and producing leases by notice subject to judicial review or appropriate judicial proceedings.

Experienced private and government personnel are aware that public attention was focused on the oil spill at Santa Barbara in January 1969, and probably because of this awareness, there has been a great deal less oil pollution in the Gulf as a result of normal oil and gas producing operations. Table A-4 summarizes the oil spills in the Gulf since 1972.

In the past, major events were cataloged while less serious events were often not reported. Some years ago, wells were on occasion intentionally flowed into the water for short periods during clean-up operations. Now, sophisticated burning devices are designed to consume this well clean-up oil without producing air or water pollution. Automatic equipment is now in use which shut-in production whenever a leak occurs in pipeline or production facilities. These include, but are not limited to, pressure sensors and high and low level controls. Drip pans are placed under valves, vessels and the production system in order to prevent leaking oil from escaping into the waters of the Gulf.

During the past four years, the average number of pipeline malfunctions which resulted in oil spillage was approximately twenty per year, with thirty occurring during 1974. This apparent increase may be attributed to: increased inspections and better reporting; increased footage of pipelines; age of existing pipelines; and damage by tropical storms (personal communication, USGS, 1975).

From January 1, 1971 through October 31, 1975 there were approximately 49,111 barrels of oil produced per barrel of oil spilled.

Contingency Action

Oil spills will occasionally occur as a result of natural disasters, equipment failure or human error. In the event that such an emergency occurs, the following action will be taken:

Requirements of OCS Order No. 7

In the case of any spill, the operator is required to initiate action to control and remove the oil pollution in accordance with his approved emergency plan. In any case, a spill or leakage of less than 15 bbls. requires a report from the operator as to the nature of the spill or leakage, the reason for its occurrence and what steps were taken to correct it. A spill of 15-50 bbls. must be reported immediately to USGS by telephone and confirmed in writing. A spill of over 50 bbls. or one of any magnitude that cannot be immediately controlled must be reported immediately to the Coast Guard, the Environmental Protection Agency and the Geological Survey.

Regional or National Contingency Plans

If the operator should be unable to control and remove the pollution, the Regional or National Oil and Hazardous Substances Pollution Contingency Plan may be activated and the designated Federal On-Scene Coordinator would direct control and clean-up operations at the operator's expense. This has never been necessary to date in the case of any spill from OCS operations.

The Regional or National Oil and Hazardous Substances Pollution Contingency Plan was developed pursuant to the provisions of the Federal Water Pollution Control Act as amended (33 U.S.C. 1101). EPA has published the revised National Oil and Hazardous Substance Pollution Contingency Plan as required by the Federal Water Pollution Control Act Amendments of 1972. Section 11(c)(2) of that statute authorized the President, within sixty days after the sections become effective, to prepare and publish such a Plan. The Plan provides for efficient, coordinated and effective action to minimize damage from oil (and other) discharges, including containment, dispersal and removal. The Plan includes: assignment of duties and responsibilities; identification, procurement, maintenance and storage of equipment and supplies; establishment of a strike force and emergency task force; a system of surveillance and notice; establishment of a national center to coordinate response operations; procedures and techniques to be employed in

identifying, containing, dispersing and removing oil; and a schedule identifying dispersants and other chemicals that may be used in carrying out the Plan and the waters and quantities which they may be safely used. Annex X of the Plan basically sets forth a no dispersant policy. Exceptions can be made for safety reasons (to prevent fire or explosions) or for certain other circumstances such as the protection of endangered waterfowl. However, the approval of EPA is required, except in cases of safety when the approval of the On-Scene Coordinator is required. The Plan is revised from time to time as necessary. Operation of the National Contingency Plan requires a nationwide network of regional contingency plans. Guidelines for that nationwide network are established in the National plan. This Plan provides for a pattern of coordinated and integrated responses of departments and agencies of the Federal Government to pollution spills. It establishes a national response team and provides guidelines for the establishment of regional contingency plans and response teams. The Plan also promotes the coordination and direction of federal, state and local response systems and encourages the development of local government and private capabilities to handle such pollution spills.

The objectives of the Plan are: to develop appropriate preventive and preparedness measures for discovering and reporting the existence of a pollution spill; to promptly institute measures to restrict further spread of the pollutant; to assure that the public health, welfare and natural resources are provided adequate protection; to provide for the application of techniques for clean-up and disposal of the collected pollutants; to provide for a scientific response to spills as appropriate; to provide strike forces of trained personnel and adequate equipment to polluting spills; to institute actions to recover clean-up cost; and to effect enforcement of existing federal statutes and regulations issued thereunder. Detailed guidance toward the accomplishment of these objectives is contained in the basic Plan, the annexed and the regional plans.

The Plan is effective for all United States navigable waters including inland rivers, the Great Lakes, coastal territorial waters and the contiguous zone and high seas beyond this zone where a threat exists to United States waters, shore-face or shelf-bottom. Its provisions are applicable to all federal agencies.

A memorandum of understanding between the Department of the Interior and the Department of Transportation outlines the respective responsibilities of the Geological Survey and the Coast Guard under the National Contingency Plan. The Geological Survey is responsible for the coordination and direction of measures to abate the source of pollution when the source is an oil, gas or sulphur well. This responsibility includes the authority to determine whether pollution control operations within a 500 meter radius of the pollution source should be suspended to facilitate measures to abate the source of pollution. The Coast Guard is responsible for the coordination and direction of measures to contain and remove pollutants, and shall furnish or provide the On-Scene Coordinator with authority and responsibilities as provided by the National Contingency Plan.

Petroleum Industry Contingency Plan

Inventory of known resources available for emergency oil spill control and clean-up

From the upper Texas coast to the Mississippi Delta region offshore operators maintain a large inventory of various kinds of equipment that could be put to use on short notice for containing and cleaning up an oil spill and killing the source of the spill. This inventory includes 177 boats ranging from 30 crewboats to 50 meter utility and cargo vessels, 64 helicopters, and 103 fixed-wing aircraft. For a complete inventory of oil spill containment and clean-up equipment see USDI, 1975b, Appendix C.

Clean Gulf Associates

Clean Gulf Associates is a non-profit organization formed by thirty-nine companies (these companies produce 98% of offshore petroleum) operating in the OCS. Their purpose is to provide for a stockpile of oil spill containment and clean-up materials for use by member companies in offshore and estuarine areas. Clean Gulf Associates has contracted, effective August 1, 1972, with Halliburton Services to supply equipment, materials and personnel necessary to contain and clean-up spills in the Gulf of Mexico to the limits of the OCS lying offshore and seaward of the states of Texas, Louisiana, Mississippi, Alabama and Florida.

All of the tracts considered in this proposed lease sale fall within this area. Before any drilling commences, should this proposed sale be held, an inventory of pollution combatting equipment would be stockpiled at a strategic location.

At the present time, Halliburton maintains four types of recovery/clean-up systems for development at three primary bases located at Intercoastal City and Grand Isle, Louisiana, and a subbase at Venice, Louisiana. These include: fast response open sea/bay, high volume open sea, and shallow water skimmer systems and auxiliary shallow water and beach clean-up equipment.

Effectiveness of Clean-up Operations

The effectiveness of offshore clean-up is weather contingent. The equipment which is now stockpiled and available as well as that which will be built in the near future, is not completely effective in high winds or waves. The average recovery of oil spilled at sea is on the order of 20% (Biglane, 1975).

A major problem of spill clean-up operations involves the disposal of oil contaminated debris. If a spill involves a large quantity of such debris, an acceptable disposal site must be found. The residents of shore communities are becoming increasingly reluctant to commit their disposal sites, which are of limited capacity, to this use. If the debris is not disposed of properly, secondary contamination of surface or ground waters can result.

Table A-1.—*Equipment malfunction detected January through November 1972 special inspections*

	No. checked	Operable	Inoperable or not within acceptable tolerances	Percent failure
Surface safety valves	1,533	1,480	53	3.5
Flowline sensors	3,021	2,982	39	1.3
Check valves	1,434	1,370	64	4.5
Pressure vessels:				
High pressure sensors	961	942	19	2.0
Low pressure sensors	610	600	10	1.6
High level shut-in	351	345	6	1.7
Low level shut-in	323	314	9	2.8
Total	8,233	8,033	200	2.4

Table A-2.—*Equipment malfunctions detected January through November 1973 special inspections*

	No. checked	Operable	Inoperable or not within acceptable tolerances	Percent failure
Surface safety valves	1,492	1,423	69	4.6
Flowline sensors	1,327	1,290	37	2.8
Check valves	1,469	1,385	84	5.7
Pressure vessels:				
High pressure sensors	1,100	1,077	23	2.1
Low pressure sensors	784	771	13	1.7
High level shut-in	405	398	7	1.7
Low level shut-in	383	375	8	2.1
Total	6,960	6,719	241	3.5

Source: U.S. Geological Survey, 1975.

Table A-3.—*Equipment malfunctions detected January 1974 through July 1975 equals special inspections*

	No. checked	Operable	Inoperable or not within acceptable tolerances	Percent failure
Surface safety valves	1,237	1,187	50	4.0
Flowline sensors	3,557	3,521	36	1.0
Check valves	1,420	1,324	96	6.8
Pressure vessels:				
High pressure sensors	456	450	6	1.3
Low pressure sensors	237	234	3	1.3
High level shut-in	332	322	10	3.0
Low level shut-in	418	389	29	6.9
Total	12,858	12,460	398	3.1

Table A-4.—*Summary of oil slicks and oil spills information related to oil spills which occurred from July 1, 1975 through January 31, 1976 is summarized below*

Month	No. spills	Vol. crude (barrels)	Vol. other	No. spills one barrel or less	No. slicks sighted
July	11	39		109	60
August	9	47	3 oil base mud	101	51
September	11	32	100 diesel	105	55
October	8	26	20 diesel	66	56
November	7	31	2 methanol	66	24
December	6	17		66	36
January	5	15	2 diesel	71	35
Total	57	207	124 diesel 3 oil base mud 2 methanol	584	317
Total since November 1972	438	45,712	62 Condensate 631 Diesel 47 Oil base mud 3 Distillate 10 Corrosion inhibitor 2 Methanol	1,710	1,902

Source: Geological Survey, Metairie, Louisiana (March 10, 1976)

Structures

If a ship strays from established safety fairways, oil and gas platforms can pose a hazard to commercial shipping. This hazard however, is minimized by the fact that safety fairways are clearly designated on navigation charts. Directional drilling from outside safety lanes is used to develop tracts lying partially under safety lanes. Pertinent portions of the Federal Regulations (33 CFR Sec. 209.135(b), 1971) governing shipping fairways and anchorage areas are as follows:

"The Department of the Army will grant no permits for the erection of structures in the area designated as fairways, since structures located therein would constitute obstructions to navigation. The Department of the Army will grant permits for the erection of structures within an area designated as an anchorage area, but the number of structures will be limited by spacing as follows: The center of a structure to be erected shall be not less than two (2) nautical miles from the center of any existing structures. In a drilling or production complex, associated structures shall be as close together as practicable having the consideration for the safety factors involved. A complex of associated structures, when connected by walkways, shall be considered one structure for the purposes of spacing. A vessel fixed in place by moorings and used in conjunction with the associated structures of a drilling or production complex, shall be considered an attendant vessel and its extent shall include its moorings. When a drilling or production complex includes an attendant vessel and the complex extends more than five hundred (500) yards from the center of the complex, a structure to be erected shall not be closer than two (2) nautical miles from the near outer limit of the complex. An underwater completion installation in an anchorage area shall be considered a structure and shall be marked with a lighted buoy as approved by the United States Coast Guard."

Development of those tracts in the proposed sale which lie partially within shipping fairways or anchorage areas will be subject, if leased, to Federal regulations as presented above so far as

the placement of structures is concerned. This would help mitigate any potential impact due to the proximity of structures to relatively high frequency sea traffic.

Commercial vessels are required to report to the Coast Guard whenever a casualty results in any of the following: actual physical damage to property in excess of $1,500, material damage effecting the sea-worthiness or efficiency of a vessel, stranding or grounding, loss of life or injury causing any person to remain incapacitated for a period in excess of 72 hours except injury to harbor workers not resulting in death and not resulting from vessel casualty or vessel equipment casualty. Drilling and production platforms (artificial islands) are required to report to the Coast Guard when involved in a casualty or accident and if any of the following occur: if hit by a vessel and damage to property exceeds $1,500, damage to fixed structure exceeds $25,000, material damage affecting usefulness of lifesaving or fire fighting equipment or loss of life.

Under some conditions, offshore structures are an obstacle to commercial fishing activities. Depending on currents and underwater obstacles an offshore structure can remove areas of trawling and purse seining waters. Heavy concentrations of platforms can make trawling and purse seining difficult.

The erection of more structures on the OCS may affect commercial fishing operations. The impact from platforms may be kept to a minimum by allowing only those structures necessary for proper development and production of the mineral resources, and by placing them with due regard to fishing operations and other competing uses which are evident at the time of platform approval.

The Area Oil and Gas Supervisor considers the views of commercial fishing organizations such as the Gulf State Marine Fisheries Committee with regard to placement of platforms. The Supervisor also from time to time requests information from the Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service to be used in his decision making process of approving or disapproving platform installation. Within the constraints of location of the reservoirs and the technology necessary to drill directional wells, the Supervisor is mindful that platform location is an important consideration for commercial fisheries and does make decisions regarding platform location which minimize the impact on the commercial fishing industry.

In an effort to further mitigate the impact of offshore structures resulting from this proposed sale with regard to commercial fishing and other significant existing or future uses of the leased area, a lease stipulation giving effect to the following will be applied to all blocks in this proposed offering in the event they are leased:

"Structures for drilling or production, including pipelines, shall be kept to the minimum necessary for proper exploration, development and production and to the greatest extent consistent therewith, shall be placed so as not to interfere with other significant uses of the Outer Continental Shelf including commercial fishing. To this end, no structure for drilling or production, including pipelines, may be placed on the Outer Continental Shelf until the Supervisor has found that the structure is necessary for the proper exploration, development, and production of the leased area and that no reasonable alternative placement would cause less interference with other significant uses of the Outer Continental Shelf including commercial fishing. The lessee's exploratory and development plans, filed under 30 CFR 250.34, shall identify the anticipated placement and grouping of necessary structures, including pipelines, showing how such placement and grouping will have the minimum practicable effect on other significant uses of the Outer Continental Shelf, including commercial fishing."

Pipelines

Existing Responsibilities

Federal responsibility and authority for gas and oil pipeline routing or operation on submerged coastal lands is vested in a number of agencies, including the following: Department of the Interior, Bureau of Land Management—rights-of-way for pipelines on the OCS, Environmental review and recommendations on all gathering and flow-lines under Secretarial Order 2974; Geological Survey—jurisdiction over producer owned gathering lines and flow-lines on the OCS; U.S. Fish and Wildlife Service—protection of fish and wildlife resources and their habitat through consultation with the Corps of Engineers in the process of issuing Federal permits in navigable waters. U.S. Army Corps of Engineers—issues permits for construction (including pipelines) on OCS and in other navigable waters; Federal Power Commission—grants certificates of convenience and necessity prior to construction of interstate natural gas pipelines; Interstate Commerce Commission—grants approval of the tariff rates for transportation of oil by common-carrier pipelines; Department of Transportation, Office of Pipeline Safety—establishes minimum standards for

pipeline construction, operation and maintenance; and Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service—protection of marine fishery resources and their habitat (in coordination with the U.S. Fish and Wildlife Service) through consultation with the Corps of Engineers in the process of issuing Federal permits in navigable waters.

At present, the cooperative effort between the Department of the Interior and the Corps of Engineers, and the National Marine Fisheries Service and State conservation agencies is responsible for minimizing the impact of pipeline and other construction in navigable waters of the United States. The Corps of Engineers, through authority of the Rivers and Harbors Act of 1899 (33 U.S.C. 403) asserts authority over, and requires a permit for construction in all navigable waters subject to the Submerged Lands Act (43 U.S.C. 1301) and includes all lands permanently or periodically covered by tidal waters up to the line of mean high tide.

The Environmental Protection Agency reviews and comments on dredging projects in navigable waters in accordance with a memorandum of understanding with the Corps of Engineers dated July 13, 1967.

The National Oceanic and Atmospheric Administration (through its National Marine Fisheries Service) has been vested with responsibility for participation in matters relating to marine and estuarine areas.

The Department of the Interior and its U.S. Fish and Wildlife Service has responsibility and authority under several statutes, including the Fish and Wildlife Act of 1956, the Estuary Protection Act, the Endangered Species Act of 1973, the Migratory Bird Conservation Act, the Fish and Wildlife Conservation Act, the Marine Mammals Protection Act, and various international treaties enacted to preserve, conserve, protect and enhance fish and wildlife resources and their habitat.

The U.S. Fish and Wildlife Service, with assistance from appropriate State and Federal agencies, including the National Marine Fisheries Service now reviews all applications to the Corps of Engineers for permits to construct pipelines in navigable waters and assesses their potential impact on fish and wildlife resources and the environment. When appropriate, the Agency recommends to the Corps specific modification of project plans which are needed to reduce impact on these resources. Occasionally a project plan is so conceived that significant impact cannot be avoided and at the same time, a satisfactory alternative may not be available; in such cases, a recommendation that the permit not be issued would be appropriate.

Mitigating Measures

Federal, State or local authorities or private landowners may take measures to require, depending upon circumstances and location, that pipelines be buried; that archaeological and hazard surveys be conducted; that canals in wetland areas be backfilled where possible; that bulkheads be erected and maintained in marsh areas to prevent saltwater intrusion; that specific types of dredging equipment be used and specific methods for placement or disposal of spoil be required; that beach and dune areas crossed by pipeline be restored; that pipeline installations in sensitive or valuable areas be seasonally timed so as to occur, for example, during low periods of tourist and recreational activities, or prohibited during low periods of tourist and recreational activities, or prohibited during acute periods of nesting of waterfowl or migrations of fish and wildlife.

The Department will ultimately receive applications for the OCS component of pipelines resulting from this sale, and after considering all factors, may approve pipeline rights-of-way. The procedure for this is outlined in a Memorandum of Understanding between the Bureau of Land Management and the Geological Survey for Outer Continental Shelf Pipelines. The purposes of the Memorandum is to clearly define the administrative and operational roles of the Bureau of Land Management and the U.S. Geological Survey relating to pipelines on the OCS, to provide consistent and standardized procedures, and to minimize or eliminate dual and overlapping functions. The objectives of the Memorandum are to:

Provide an efficient mechanism for approving pipeline routes through the submerged lands of the OCS.

Initiate measures to provide safety and to minimize or eliminate environmental damage which may be associated with the installation and operation of pipelines originating on the OCS.

Be responsive to the interests of the oil and gas industry, other users of the OCS, and the public with respect to pipelines.

Streamline implementation of the regulations and procedures for more efficient and uniform administration of the Department's authority with respect to pipelines.

The Bureau of Land Management's role in pipeline management on the OCS is defined as follows:

Conduct pipeline routing studies and, with the concurrence of the USGS, designate pipeline corridors on the OCS for all pipelines other than flow or gathering lines within the confines of a single lease or group of contiguous leases under unitized operation or a single operator.

Maintain a central office of record for the location of all existing and future pipelines as specified in paragraph I.A. and associated structures on the OCS.

Prepare environmental assessments, pipeline system planning studies, economic studies, and environmental impact statements when necessary or appropriate, prior to approving applications for rights-of-way pursuant to 43 U.S.C. 1-34(c) and 43 CFR 2883.

Receive applications for rights-of-way for pipelines to be installed on the OCS pursuant to 43 U.S.C. 1334(c) and 43 CFR 2883.

After considering the potential impact of the pipelines on the environment, the relationship of the application to existing pipeline routes on the OCS, and other factors, approve or disapprove the application pursuant to 43 CFR 2883.

This memorandum notwithstanding, some potential adverse effects related to OCS induced pipeline sitings occur nearshore and onshore and generally remain outside BLM authority to apply direct mitigatory measures. However, the ability to regulate pipelines on the OCS implies certain influence over the allocation of nearshore and onshore response. The ability represents a management tool with the potential to indirectly mitigate many adverse effects of random pipeline placement in areas beyond BLM authority. The ability to structure one component of a total transportation system permits a greater degree of departmental management, control and environmental responsiveness of federal, industry and state expressions of pipeline requirements and siting policy; offshore and onshore are integrated during pre-planning stages.

The Department plans to optimally structure sale-related pipeline development and locational schemes for tracts leased in this proposed sale as per our responsibility for pipeline system planning on the OCS. Optimum pipeline development is partly a function of offshore and onshore environmental capabilities, operational and economic dictates and the transportation needs of the impacted area. Recognition of these parameters in a coordinated federal, state and industry effort will result in pipeline sitings which recognize zones of least environmental impact and economic feasibility, according to articulated studies, plans, policies and controls. Such an effort is anticipated before the granting of pipeline rights-of-way induced by this proposed sale.

Special Studies

Several scientific investigations are being conducted in the Gulf of Mexico in order to obtain data that may be used in future evaluations of offshore leasing (Table D-1). These are discussed below.

The first year included mapping and submersible reconnaissance of 16 topographic highs (Table D-2) on the Texas OCS and has been completed. The reconnaissance allowed for visual (operators' reports, videotape and still photographs) characterization of these sites as potentially valuable resources (commercial fish havens, reefs or reef-type communities). Biological and geological sampling was also conducted. Much of this information was utilized in the promulgation of lease stipulations.

In the second year of this study further intensive submersible observations and standard oceanographic measurements will be taken at Southern Bank and Hospital Rock. Bathymetric mapping will be completed for East Flower Garden, Stetson and an unnamed bank. Submersible reconnaissance will be conducted at the Stetson, East Flower Garden, Twenty-eight Fathom Banks and the adjacent unnamed bank. The work is being conducted on this latter group in order to precede anticipated drilling activity.

A second recently completed special study entitled "Compilation and Summation of Historical and Existing Physical Oceanographic Data from the Eastern Gulf of Mexico" summarized available data of the Gulf of Mexico Loop Current, West Florida Shelf Currents, meteorological factors affecting oceanographic conditions, river runoff effects in the MAFLA area, remote sensing data and the results of several drift bottle releases in the Gulf of Mexico. This information is and has been utilized in the planning and development of present and future studies in the MAFLA area. In addition, it has provided substantive information on the evaluation of potential areas of impact.

A third special study, partially funded by the BLM, will attempt to develop the capacity to predict currents in the Gulf of Mexico for use in pollutant trajectory computations.

The onshore coastal zone is diverse and varied in its environmental values and tolerances to pipeline construction. Because of cultural or natural values some areas may be highly suitable for such activity, while other areas may exhibit

severe constraints. The control of potential onshore impacts from overland pipeline construction remains in the hands of state and local authorities or landowners, since federal authority over pipeline placement is limited in a shoreward direction to navigable waters and adjacent wetlands. The coastal zone management program presently under development in the five gulf states will provide them with a further mechanism for controlling such potential impacts. Should sufficient production result from the OCS which warrants new pipeline landfalls, BLM will participate with the states in identifying those areas which are most intrinsically suitable for pipelines and related developments onshore.

On December 21, 1974, the Assistant Secretary of the Interior requested that the National Petroleum Council undertake a study concerned with the availability of materials, manpower and equipment necessary for the exploration and production of oil during the subsequent two years. The results of this study were published during September, 1974 by the National Petroleum Council under the title "Availability of Materials, Manpower and Equipment for the Exploration, Drilling and Production of Oil—1974–1976".

BLM field offices periodically review information available in their areas concerning several factors, including the availability of materials, manpower and equipment necessary for the conduct of exploration and production activities.

Table D-1 —*Status of BLM Environmental Studies in the Gulf of Mexico and South Atlantic OCS.*

Title	Contractor	Status
Bibliography for the Gulf of Mexico OCS.	Environmental Consultants	Final report accepted.
MAFLA Environmental Baseline Study.	SUSIO	Final report accepted.
MAFLA Baseline and Rig Monitoring	SUSIO	Field sampling complete.
South Texas OCS Environmental Studies Geology	USGS, Corpus Christi	Final Report accepted.
South Texas OCS, Biology and Chemistry	Texas Universities	Draft Final Report Submitted.
South Texas, OCS, Historical Fisheries and Physical Oceanography	NOAA	Draft Final Report Submitted.
South Texas OCS Second-Year Environmental Studies, Geology	USGS, Corpus Christi	Sampling initiated in November 1975 and presently ongoing.
South Texas OCS Second-Year, Biology and Chemistry	Texas Universities	Field sampling underway, initiated in January 1976.
South Texas OCS Second-Year, Ichthyoplankton Survey and Historical Zooplankton Analysis	NOAA	Analysis underway.
South Atlantic OCS Conference/Workshop	Research Triangle Institute	Final report accepted.
South Atlantic OCS Environmental Studies	Contracts not let	RFP's to be released in April–May 1976.
Texas Topographic Highs Study	Texas A&M	Final report accepted
Texas Topographic Highs Study, Second Year.	Texas A&M	Sampling underway submersible work scheduled for August 1976.
Historical Physical Oceanography of Eastern Gulf of Mexico.	SUSIO	Final report accepted
Quality Control of Hydrocarbon Analysis for MAFLA and South Texas OCS Studies.	University of New Orleans	Final report due July 1976.
Quality Control of Trace Metal Analysis for MAFLA and South Texas OCS Studies.	Gulf South Research Institute	Final report due September 1976.
Multivariate Analysis of MAFLA Water Column Data.	University of Florida	Draft final submitted.
Hydrocarbon Analysis of MAFLA Benthos.	University of Michigan	Draft final submitted.
Gulf of Mexico OCS Cultural Resource Sensitivity Zone Mapping Project.	Coastal Environments, Inc.	Final report partially received.

Table D-1 —*Status of BLM Environmental Studies in the Gulf of Mexico and South Atlantic OCS.*

Status of Fish and Wildlife Environmental Studies in the Gulf of Mexico Region

Title	Contractor	Status
Analysis of Onshore, Estuarine and Marine Effects of Coastal and Outer Continental Shelf Oil and Gas Development on Fish and Wildlife Resources and Coastal Ecosystems	The Conservation Foundation Washington, D.C.	Contract Awarded Fall, 1975
Colonial Nesting Sea and Wading Bird Survey	Louisiana State University Cooperative Research Unit Baton Rouge, Louisiana	Preliminary Report submitted
Ecological Characterization of the Chenier Plain of Southwestern Louisiana and Southeastern Texas	Energy Resources Incorporated Cambridge, Massachusetts	Contract Awarded April, 1976
Development of Methods and Guidelines to Protect Fish and Wildlife Resources and Supporting Habitats during Gas and Oil Operations on Refuges and Other Public Lands		RFP Published May, 1976

Table D–2—*Sites surveyed during the first year.*

1. 29 Fathom Bank—92° 29.25′, 28° 08.5′	9. Southern—96° 31.05′, 27° 26.05′
2. 28 Fathom Bank—93° 26.4′, 27° 55.0′	10. Dream—96° 42.5′, 27° 02.5′
3. Little Sister—94° 14.5′, 27° 52.0′	11. Big Adam—96° 48.5′, 26° 57.5′
4. 32 Fathom Bank—94° 32.0′, 28° 03.7′	12. Blackfish Ridge—96° 46.5′, 26° 52.7′
5. Baker—96° 13.5′, 27° 45.0′	13. Mysterious—96° 42.5′, 26° 46′
6. South Baker—96° 16.4′, 27° 40.25′	14. Small Adam—96° 51.0′, 26° 56.5′
7. Aransas—96° 27.0′, 27° 35.3′	15. North Hospital[1]
8. Hospital—96° 29.0′, 27° 33.2′	16. East Flower Garden[2]

[1] Submersible observations
[2] Mapping not performed

Other Mitigating Measures

Special Stipulations

Leases for oil and gas exploration and development are subject to all OCS operating regulations and orders. Additionally, in some cases, the lease may include special stipulations which are considered necessary for the protection of a particular resource or activity.

Section 2(b) of Executive Order 11593 requires that, until inventories and evaluations can be completed, caution should be exercised over federally owned property in order to avoid damage or alteration of cultural resources potentially suitable for inclusion on the National Register of Historic Places. A Department of the Interior study is currently under contract to identify areas of the Gulf of Mexico which contain, or have a high potential for containing, significant historical or archaeological resources.

It is proposed that the following stipulations be applied to any lease resulting from this proposed sale for the protection of historical, archaeological or architectural values on the OCS:

If the Supervisor, within one year from the effective date of this lease, gives the lessee written notice that the lessor is invoking the provisions of this stipulation, the lessee shall immediately upon receipt of such notice comply with the following requirements:

Prior to any drilling activity or the construction or placement of any structure for exploration or development on the lease, including, but not limited to, well drilling and pipeline and platform placement, hereinafter referred to as "operation", the lessee shall conduct surveys to determine the potential existence of any cultural resource that may be affected by such operation. Such surveys may include, but need not be limited to, data obtained by remote sensing equipment and/or visual inspection or testing.

All data produced by such surveys shall be examined by a qualified marine archaeologist or archaeological surveyor to determine if anomalies are present which suggest the existence of a cultural resource that may be adversely affected by any lease operation.

If such anomalies exist, the lessee shall: (1) locate the site of such operation so as not to adversely affect the anomaly identified; or (2) establish, to the satisfaction of the Supervisor, on the basis of further archaeological investigation conducted by a qualified marine archaeological surveyor using such survey equipment and techniques as deemed necessary by the Supervisor, either that such operation will not adversely affect the anomaly identified or that the potential cultural resource suggested by the occurrence of the anomaly does not exist.

Upon completion of any remote sensing or other survey conducted for archaeological purposes, the lessee shall forward a report prepared by the marine archaeologist or archaeological surveyor to the Supervisor for his review. Should the Supervisor determine that the existence of a cultural resource which may be adversely affected by such operation is suffiently established to warrant protection, the lessee shall take no action that may result in an adverse effect on such cultural resource until the Supervisor has given directions as to its disposition.

The lessee agrees that if any site, structure, or object of historical or archaeological significance should be discovered during the conduct of any operations on the leased area, he shall make every reasonable effort) preserve and protect the cultural resource from damage until the Supervisor has given directions as to its disposition.

Archaeological reports covering leases issued as a result of this proposed sale will be submitted to the Supervisor of the USGS and to the Manager of BLM. The Equipment and procedures to be used in conducting archaeological surveys and the format of the reports have been agreed upon by BLM, USGS and the National Park Service, and are published by the Geological Survey Supervisor as Notice to Lessees and Operator 75-3.

The Manager will review these reports and provide the Supervisor with recommendations for protection of any known or potential cultural resources identified therein. The Supervisor will consider these recommendations and any other relevant information at his disposal prior to issuing a permit for operations at a specific location with a lease.

Data compilation by the Bureau of Land Management and other studies indicate fishing or hard bank biological communities are located in certain tracts within this proposed lease sale. This stipulation will be applied to tracts 10, 11 and 61 and is designed to protect these areas.

The lessee agrees that, prior to any drilling activity or placement of any permanent production platform or pipeline, he will submit as part of his exploration and/or development plan, a bathymetry map with an interpretation as to the presence and location (or absence) of hard bank biological communities. After consultation with the Manager, New Orleans OCS Office, Bureau of Land Management, and the Regional Director, U.S. Fish and Wildlife Service, Atlanta, Georgia, the Oil and Gas Supervisor, U.S. Geological Sur-

vey, Metairie, La., may approve exploration and/or development plans. During the exploratory and development phases, the lessee will provide the Supervisor with a written log detailing a description of the materials introduced into the marine environment and manner of this disposition.

To apply to all leases resulting from these lease sales.

Structures for drilling or production, including pipelines, shall be kept to the minimum necessary for proper exploration, development, and production, and to the greatest extent consistent therewith, shall be placed so as not to interfere with other significant uses of the Outer Continental Shelf including commercial fishing.

To this end, no structure for drilling or production, including pipelines, may be placed on the Outer Continental Shelf until the Supervisor has found that the structure is necessary for the proper exploration, development and production of the lease area and that no reasonable alternative placement would cause less interference with other significant uses of the Outer Continental Shelf, including commercial fishing. The lessee's exploratory and development plans, filed under 30 CFR 250.34, shall identify the anticipated placement and grouping of necessary structures, including pipelines, showing how such placement and grouping will have the minimum practicable effect on other significant uses of the Outer Continental Shelf, including commercial fishing.

The lessee shall have the pollution containment and removal equipment available as required by OCS Order No. 7, of August 28, 1969, as may be amended. After notification by the Operator to the Supervisor of a significant oil spill as defined by OCS Order No. 7, or any oil spill of any size or quantity which cannot be immediately controlled, the operator shall immediately deploy the appropriate equipment to the site of the oil spill, unless, because of weather and attendant safety of personnel the Supervisor shall modify this requirement.

Notices to Lessees and Operators

These notices have the same effect or status as OCS Operating Orders and Regulations and are used when expeditious clarifications or corrections and additions to existing orders and regulations are necessary. By issuing Notices to Lessees and Operators, the extensive amount of time necessary to amend and republish orders and regulations is avoided.

Departures

A departure (waiver) from OCS orders or other rules of the U.S. Geological Survey, may be granted by the Supervisor when such a departure is determined to be necessary for (30 CFR 250.12(b)): the proper control of a well, conservation of natural resources, protection of aquatic life, protection of human health and safety, protection of property or protection of the environment.

Waivers are technically based decisions and are granted only in situations in which expert judgement determines that better and safer operations would result from operations under the waiver.

Research on Advanced Technology

The EPA and the Coast Guard are conducting research on more efficient containment and recovery devices (booms and skimmers). The efficiency of booms and skimmers depends on sea state and spill conditions but in any case they are never 100% efficient.

When the results of these studies and any other similar studies so indicate, the requirement for use of better techniques and equipment will be incorporated into the OCS regulations and orders as appropriate. If incorporated, the requirements will be applied to all leases.

Geophysical Information

The Conservation Division of the Geological Survey is aware of near-surface structural configurations and its effect on drilling, fixed-structural emplacement, pipelines, etc., in relation to the proposed lease tracts. Knowledge of near-surface structural conditions is fundamental to a sound lease management program for the OCS.

Geophysical data which show the shallow structural and sedimentary environment are used to predict, thereby minimizing any geologic hazards to drilling operations and consequent possible dangers to the environment from pollution. When surface and shallow subsurface geologic hazards are properly identified and correlated with surrounding strata, they seldom create insurmountable obstacles for a minimal risk program of exploration and exploitation involving economically attractive structures.

High-resolution geophysical data covering all tracts to be offered for this proposed sale will be purchased by GS and analyzed by GS geophysical personnel. These data provide definitive information on the thickness of unconsolidated sediments; structural configurations of shallow seismic horizons; sea floor anomalies, mud mounds, mud waves and potential slide areas; pipelines and other objects on the sea floor, and suitable locations for bore holes as interpreted from a combined analysis of several geophysical measurements and bathymetry.

Information from these high resolution data are extremely useful in detecting shallow geologic hazards such as potentially unstable bottom conditions (mud waves, etc.), shallow faults, and in some cases, near surface solution cavities. When these features are identified prior to drilling operations or platform construction, the operator

is notified so that he can take the necessary action which will further insure that operation will be conducted with maximum safety.

Interpretations of high resolution subbottom profile data which disclose bottom and subsurface conditions posing a special environmental hazard for drilling or production operations in the offshore area will be made available to the Bureau of Land Management prior to the decision to issue a lease, and to the Geological Survey prior to the approval of drilling operations. If it becomes necessary, the District Engineer, Geological Survey, will prohibit the placement of platforms on areas of instability through his authority to issue or not issue permits for platform placement.

A departure (waiver) from OCS orders or other rules of the GS Supervisor may be granted when such a departure is determined to be necessary for (30 CFR 250.12(b)) the proper control of a well; conservation of natural resources; protection of aquatic life; protection of human health and safety, and protection of property and the environment.

Conservation Practices

In the interest of conservation, the GS Oil and Gas Supervisor is authorized, pursuant to the Code of Federal Regulations, to approve well locations and well spacing programs necessary for proper development, to give consideration to such factors as the location of drilling platforms, the geological and reservoir characteristics of the field, and the number of wells that can be drilled economically, the protection of correlative rights and the minimizing of unreasonable interference with other uses of the outer continental shelf. The Supervisor draws his authority from the following regulations and OCS operation orders:

30 CFR 250.11 outlines in broad terms the GS Supervisor's authority to control development of the OCS to protect the natural resources of the OCS, and to obtain maximum economic recovery of mineral resources under sound conservation practices.

30 CFR 250.16 authorizes the GS Supervisor to specify the permissible production of a well. Thereafter, OCS Order No. 11 establishes the production rate control at the Maximum Efficient Rate (MER) of the well or reservoir.

30 CFR 250.17 deals with well spacing, authorizes approval of well locations, and platform locations and lists factors for consideration in this regard.

30 CFR 250.30 requires lessee's compliance with OCS Orders and general regulations, and demands all necessary precautions to prevent damage, waste and injuries.

30 CFR 250.34 requires that lessee submit to the GS Oil and Gas Supervisor exploratory drilling plans, lease development plans and applications for permits to drill prior to these programs. The GS Oil and Gas Supervisor utilizes well information such as electric well logs, core information from other wells previously drilled in the vicinity of the proposed drilling program, geological and geophysical data and other pertinent reservoir information in order to determine the proper number of wells which are necessary for development.

350 CFR 250.50 grants the Director authority to demand pooling or unitization which the Secretary is authorized to require under the OCS Lands Act in the interest of conservation.

350 CFR 250.51 refers to the unit plan regulations contained in 30 CFR 226 with regard to obtaining approval of units or cooperative agreements.

30 CFR 250.52 lists purposes for which the GS Supervisor may approve pooling or drilling agreements.

Other Requirements

In addition to the Interior Department's requirements, the operator must comply with applicable navigation and inspection laws and regulations administered by the U.S. Coast Guard. These relate to the safety of personnel and display of prescribed navigational lights and signals for the safety of navigation. Permits to install islands and fixed structures and the drilling of wells from mobile drilling vessels must also be obtained from the U.S. Army Corps of Engineers, which is authorized by the OCS Lands Act to prevent obstruction to navigation. The decision as to whether a permit will be issued by the Corps of Engineers is based on an evaluation of the impact of the proposed work in the public interest. "All factors which may be relevant to the proposal will be considered; among those are conservation, economics, aesthetics, general environmental concerns, historic values, fish and wildlife values, flood damage prevention, land use classification, navigation, recreation, water supply, water quali-

ty, and in general, the needs and welfare of the people'' (Department of the Army Permit Public Notice No. 74-547, January 6, 1975). Pipeline construction must also be in compliance with standards established by the Office of Pipeline Safety, Department of Transportation. The Department of Labor establishes Occupational Safety and Health Standards which are applicable to OCS operations.

Operators must comply with the requirements of the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500; 86 Stat. 816) which establishes a National Pollutant Discharge Elimination System 40 CFR Part 125, F.R. 13528 (1973). This system applies to discharge on the OCS from any point source and requires any persons to obtain a permit from the EPA for the discharge of any pollutant as defined by the Act. Discharges of any pollutant without the necessary permit from EPA is made unlawful by the Act. Pursuant to section 501(b) of the Act, the Department of the Interior has suggested to EPA that the feasibility of a memorandum of understanding between the two agencies be considered in order to facilitate the administration of the NPDES as it applies to discharges arising from OCS lease operations and to minimize any redundancy of efforts by the Geological Survey and EPA. This feasibility study is currently under consideration.

The U.S. Geological Survey also establishes GS Safety Requirements pertaining to OCS operations:

Geological Survey Standard, Outer Continental Shelf No. 1 (GSS-OCS-1) defining the safety requirements for drilling operations in a hydrogen sulfide environment was published in the Federal Register, Vol. 41, No. 42, March 2, 1976. This standard will be referenced in the Hydrogen Sulfide Section of OCS Order No. 2.

UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

As described throughout this impact statement, certain features of oil and gas operations cause adverse effects which may be considered unavoidable in the light of current operational practices, technology and regulation. Some of the effects of an oil spill are considered unavoidable and are discussed below with other non-oil related impacts.

Effects on Marine Organisms

It is known that certain oil and gas operations result in temporary increases in turbidity. These operations include the discharge of drilling mud and cuttings and the excavation of pipeline trenches by jetting and dredging. When particulate matter is generated near the water surface, the depth of the penetration of sunlight will diminish. This leads to a decrease in the output of the photosynthetic mechanism of the phytoplankton, resulting in a decrease in primary productivity.

The effect of any decrease in primary production must be considered as an adverse impact. The area involved is unquantifiable but very small and any reduction would only occur locally and would not involve the entire population of marine organisms.

The area to be effected from discharged drill mud and cuttings and pipeline burial cannot be quantified. Several factors determine the possible impact: drill mud composition and weight; water currents; sea conditions; velocity of materials through disposal pipe; water depth of disposal pipe and size of pipe; type of substrate being drilled; size of drill hole and volume of cuttings; geographic location of drilling platform in Gulf of Mexico; and the dispersion rate of drilling mud in the water column.

In order to assess the impact of pipelines, water currents, sea conditions, water depths, bottom sediment and the dispersion rate of bottom sediments in the water column must be considered. The area affected is localized within fifty feet of the particular operation throughout the water column; however, this area may decrease or increase because of the many variables involved. An estimated 50 to 100 miles of new pipeline will be associated with the development of the offered tracts.

If discharge reaches the bottom in sufficient enough quantities, clogging of the respiratory surface and filter-feeding mechanisms in the benthic animals could probably reach a severe level; physiological stress, and possible mortality could result. This impact will be encountered during pipeline jetting operations and will be restricted to the downstream direction of the bottom current. The duration of the turbidity in any given area is usually no longer than a few hours.

Each well drilled from a platform will result in an expanse of cuttings that are released during drilling, which could possibly bury and smother all non-motile benthic forms below it. The cuttings normally form irregular sized mounds, depending on the currents, etc. which make quantification difficult. If the cuttings are different in texture and composition from the surrounding sediment, it may not be colonized by local forms. The significance of such a potential local population shift is unknown.

Exposure of biota to harmful or toxic materials released into the marine environment or coastal marsh such as from accidental spills of crude oil, fuel and solvents will bring about an unquantifiable adverse effect. The effects of heavy concentrations of crude oil and petroleum derivatives, depending on their composition, include lethal toxicity, sublethal effects, coating with weathered oil, long term effects from tar ball formation, and behavioral changes and habitat changes. In addition, more subtle effects of chronic contamination may be serious, but they are not fully understood at this time.

Wetlands and Beaches

No new pipelines are anticipated to come ashore as a result of this proposed sale. However, should any occur, the unavoidable short-term impacts associated with trenching and backfilling for pipeline construction include the uprooting of all plants and non-motile animals in the path of the pipeline, thereby leaving a barren strip 9 to 12 meters wide. Some slight damage may also be rendered to vegetation in adjacent areas by machinery used in the operation. The long-term impacts may include salt-water intrusion, changes in floral and faunal components and a possible increase in marsh erosion if the canal is not backfilled.

In the event of an onshore oil pipeline leak or spillage at onshore facilities, it is inevitable that the vegetation would be affected to an extent that would be dependent upon the severity of the spill. While a small leak may do little damage, a severe leak may contaminate the substrate and kill the

vegetation that comes into direct contact with the oil and several years may be required for recovery. Small animals in contact with the oil would probably be killed.

A considerable number of beaches and barrier islands are located throughout the area encompassed by this proposed sale. There are no tracts offered in this proposed sale that pose a threat to recreational beaches. However, if any of these beaches are contaminated by oil, an undetermined amount of fish and wildlife habitat (primarily birds) will be damaged. Although large numbers of bird deaths from oil spills have not been documented in the Gulf of Mexico, it is highly possible that a large number of deaths would occur should a large spill reach shore.

Deterioration of Air Quality

The air quality near offshore production sites may be affected should this proposed sale proceed. Although various types of emissions will be unavoidable, they are not expected to significantly contribute to reaching minimum air quality standards. In most cases, these emissions will be local in nature and be quickly dissipated by climatic conditions. Slight additions of emission to the onshore air quality will result from the normal operating procedures of storage, treatment and terminal facilities but should not add significantly to the pollutants already present.

If a natural gas leak or blowout were to occur, degradation would be minimal. It is expected that the methane pollutants would quickly volatilize and drift away. In the case of fire, pollutants would be largely carbon dioxide and water vapor. Oil leaks and oil spills which would not be accompanied by a fire would introduce highly volatile, low molecular weight hydrocarbons such as benzene and toluene into the atmosphere. These lighter fractions of crude oil would undergo some unknown degree of degradation, possibly resulting in photochemical smog. If a spill were to result in a fire, large amounts of particulate carbon and oxides of carbon, along with smaller but unknown amounts of sulfur oxides, nitrogen oxides, evaporate crude oil liquids and partially oxidized compounds would enter the air. Local air quality would be severely degraded during the duration of the fire. The extent of degradation cannot be determined but it is unlikely that it would be high enough to effect land resources or human health. Should a fire occur, the resultant impact would be considered adverse and unavoidable.

Deterioration of Water Quality

Water quality will be temporarily degraded by resuspension of sediment during pipeline construction and burial. The jetting away of the substrate from beneath the pipeline will result in suspension of sediments which may contain pollutants such as heavy metals and pesticides. The area affected will be in the direction of the current movement. Various other phases of offshore operations (emplacement of re-entry collars, blowout preventers, drilling platforms, etc.) will also cause suspension of bottom sediments in a localized area. The magnitude of deterioration depends on numerous variables, among them bottom type, currents and duration of the activity.

During drilling operations, discharged drill cuttings will adversely affect water quality. The severity of this impact depends upon such factors as the volume and type of mud discharged and the volume and type of cuttings discharged.

The production and discharge of formation waters (oil field brines) may contribute to water quality degradation when released into the Gulf. Produced formation waters may contain toxic substances, heavy metals, dissolved hydrocarbons and inorganic salts. The heavy metals may include cadmium, chromium, copper, lead, mercury, nickel and zinc, although these are generally present in trace quantities (EPA, 1974). The constituents of these brines may vary from formation to formation and within a single formation.

Water quality will also be somewhat affected by chronic pollutants and occasionally by a more significant spill.

Interference with Commercial Fishing Operations

As described in earlier sections, trawling operations suffer interference and inconvenience from oil and gas operations in several ways. A small area of the sea floor, up to 0.02% (approximately 0.4 hectare) of each tract leased, is occupied by drilling rigs and platforms and is unavailable to trawl fishermen. Based on past exploration success rates, up to 101 hectares of sea floor (less than one percent of the total acreage offered) may be occupied by platforms resulting from this proposed sale. Trawl nets reportedly become snagged on underwater stubs and unburied pipelines, causing damage or loss of the nets. Less frequently, large objects which were lost

overboard from petroleum industry boats and platforms are caught in trawling nets, resulting in damage to the net and/or its catch of fish; however, frequency of occurrence of this type of incident is low.

Commercial fishermen would probably not trawl in the area of an oil spill, as spilled oil could coat or contaminate commercial fish species, rendering them unmarketable. This would be another adverse effect to commercial fishing.

Interference with Ship Navigation

Very little navigational interference can be expected between ships that are utilizing established fairways and drilling rigs and platforms. However, at night, and especially during rough weather, fog and heavy seas, ships which are not navigating the fairways could collide with fixed structures. Also, fishing boats engaged in trawling will be inconvenienced by having to navigate around fixed structures located on fishing grounds. Based on U.S. Geological Survey estimates, 20-50 new platforms could result from this proposed sale; although the increment is small in comparison to the approximately 2,040 platforms existing in the Gulf of Mexico, it still represents a potential increase in possible interference with ship navigation.

Damage to Historical and Archaeological Sites, Structures, and Objects

Prior to the laying of a proposed pipeline or the drilling of an offshore well, geophysical surveys will be conducted in those areas considered to have a potential for containing cultural resources. These survey records will be analyzed by a marine archaeologist so that loss or damage of these resources may be avoided. Two possibilities for damage to underwater cultural resources will still remain. The first would arise if a cultural resource, for example, an early shipwreck, is encountered in an area of the shelf where expectation of its occurrence is too low to have required a pre-development underwater survey. The chance of this occurring is very low because, at the present time, all tracts leased to a depth of approximately 50 meters will require cultural resource surveys. A study is also underway which will allow for future delineation of high and low probability areas for the offshore occurrence of cultural resources. The second possibility would arise if geophysical instruments failed to record, or if analysis of the survey records failed to interpret a cultural resource in the area surveyed. No estimate of the probability of such an occurrence can be made at this time; however, underwater cultural surveying is a new field and the quality of instrumentation and experience of personnel is steadily improving. The probability of destruction of cultural resources as a result of the above circumstances should be small and will diminish in the future.

Other damage to archaeological resources may result from oil contamination. Historical and archaeological materials which are soiled by an accidental oil spill may not survive subsequent cleaning and restoration efforts. Porous materials contaminated with oil would be difficult if not impossible to date by using carbon dating techniques and a significant loss of scientific knowledge may result. Although the possibility of contamination of cultural resource materials by oil spills exists, this potential is very small. Even if an oil spill occurs, it is uncertain if artifacts lying on the bottom or beneath bottom sediments would be measurably affected by an oil slick covering the water above.

Interference with Recreational Activities

Interference with recreation is closely related to degradation of aesthetic values. Oil-contaminated beaches, freshly cut pipeline route terminals and other support facilities would normally be avoided by those seeking sites for recreational activities or for recreational development. Disturbance of beaches by pipeline burial operations will be shortlived, relative to recreational use. Oiled beaches may require days, weeks or years for adequate restorations if they become damaged. The uncertainty of accidental spills is applicable to this event also, but if spilled oil ever reached the beach, it would have an adverse effect on recreational opportunities.

The summary risk analysis lists a number of tracts which, because of their proximity to known resources and activities, may result in damage if 1,000 bbls. or more of oil were spilled and drifted toward that resource or activity area. The number of such tracts which could threaten recreational values is listed below by type of value.

Endangered species, 3 tracts
Commercial and sport fishing, 4 tracts
Outdoor recreation, 5 tracts
Cultural resources, 5 tracts

Degradation of Aesthetic Values

Platforms and drilling rigs may be located in twenty-one tracts included in this proposal lying from six to twenty-seven kilometers offshore. Some of these may be visible from shore. No new pipeline terminals or treatment facilities are expected to be constructed as a result of this proposed sale.

If structure location were to interfere with residential or recreational vistas, the visual effect would probably be considered adverse. However, the incremental addition to what already exists in the region would be small, therefore potential impact is considered minimal.

Spilled oil and debris which would float in the water or wash up on the beach would also severely detract from the scenic values of any local area. Before the natural terrain and vegetation has been completely restored, the effects of pipeline burial will appear as a large scar traversing the beach and coastal lands. Restoration over most of the scarred area will require at least one year. If a pipeline enters a forested shore, the corridor would be visible for as long as the line is maintained and for several years thereafter. Since no new lines are expected to go ashore, these impacts are considered insignificant.

Conflict with Other Uses of Land

As discussed in the Other Impacts Section regarding induced industrialization in the coastal zone it is anticipated that excess capacity in the existing gas and oil related infrastructure in the coastal zones of the adjacent states are expected to absorb most of the sale related land use inducements. A total of 0-32 hectares (required for 0-2 terminal storage facilities) was identified as the only incremental land use demand induced by the proposed sale. This acreage is very small, and there are undoubtedly alternative sites available in the general areas identified which could host such facilities. If properly sited in accordance with a comprehensive land use plan, these facilities should present no conflict with other land uses.

Summary

In summary, all unavoidable adverse impacts that will be sustained by the natural environment as a result of routine operations will be relatively localized in their effects. Many will be followed by unhindered natural recovery within relatively short time periods. A massive accidental oil spill could result in severe and widespread damage of major consequence. Therefore, all the tracts identified for oil and gas production in this proposed sale do contain varying degrees and types of adverse impact potentials. Only a massive oil spill accident would result in significant adverse impacts; however, the probability that such a massive spill will occur is relatively low.

RELATIONSHIP BETWEEN LOCAL SHORT-TERM USE AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The principal short-term use of the proposed sale area will be the extraction of oil and gas from those tracts which prove economically productive. This mineral extraction will contribute to the diminishment of the long-term productivity of the oil and gas resources of the Gulf of Mexico and possibly to marine and coastal resources.

This proposed sale, if implemented, will add approximately 56,658 hectares (USGS estimate) to the current total of almost 3.3 million hectares now under lease. This will account for 2.0% of the total area under lease after the leases of this proposed sale are included.

There are no scientific data available in this area which indicates any trend in productivity or stress to the environment that may be occurring as a result of leasing. However, it can be stated with certainty that any additional platforms that are constructed will add to the ''artificial reef'' concept and may in fact be enhancing the overall productivity of the area on the long-term basis. Data from the Gulf Universities Research Consortium (1974) provided limited data that infers that no stress or inhibited productivity is occurring as a result of offshore leasing. Beyond this, it is not possible to establish any definite conclusions.

It is recognized that chronic low-level pollution from oil and toxic chemicals will have adverse impacts in certain areas. Again, it is not possible to quantify or estimate the short or long term effects of chronic low-level pollution or even the location of its occurrence.

Assuming the installation of 20 to 40 platforms, approximately 80-160 hectares would be removed from future trawling by commercial fishermen, resulting in a decrease in long-term harvest to the trawl fishermen. However, the addition of the platforms will increase the long-term productivity for sport fishermen and commercial hand line fishermen. Unburied pipelines beyond the 61 meter contour will provide additional substrate for organisms and may thus increase the long-term productivity for certain benthos.

Disturbance of coastal land by pipeline construction and burial operations (including salt water intrusion) and construction of related onshore facilities (refineries, terminals, etc.) would decrease productivity if any of these facilities should be constructed.

Some leveling out in the number of platforms is expected as older fields become inactive or hydrocarbon production decreases. This is also true in regard to the cumulative numbers and length (in miles) of pipeline coming ashore. In the case of pipelines, as more and more areas begin to approach termination of production, some additional capacity will be available in existing pipelines to carry production from new areas thereby reducing the numbers of new pipelines required from subsequent lease sales. It is not possible to determine at this time if the total number of platforms and pipelines required to develop the OCS areas in the Gulf of Mexico has peaked, but indications are that conditions are approaching a leveling off point.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Mineral Resources

Leasing of the proposed tracts in this sale would permit development and extraction of the minerals contained therein. This proposed lease sale could result in production of between 100-200 million barrels of oil and one-three trillion cubic feet of gas which would represent an irreversible and irretrievable commitment of mineral resources.

Land Resources

It has been estimated that zero-two terminal storage facilities may result from this proposed sale. This would represent a long-term use of land resources, but not an irreversible and irretrievable commitment.

Fish and Wildlife Resources

An irreversible or irretrievable commitment of fish and wildlife resources and their habitats could occur in the area of a massive oil spill or in an area frequently subjected to chronic low-level oil pollution. However, it is anticipated that once an area recovered from a spill that the natural fauna (excluding an endemic endangered species population) would reoccupy a vacated habitat.

Cultural Resources

Any damage to archaeological sites will comprise an irretrievable commitment of non-renewable resources.

ALTERNATIVES TO THE PROPOSED ACTION

Hold the Sale in Modified Form

Sale Modification Alternatives

Delete tracts

The proposed sale could be modified by offering only those tracts which are estimated to be gas producing. This would avoid some of the potential adverse environmental effects related to this proposed sale. It could significantly reduce the potential hazard to the environment from possible oil pollution events that could result from this sale as proposed.

With this modification, the proposed sale could go forward with few adverse impacts expected as a result of oil pollution on the marine and coastal environments, resources and related activities of the area offshore.

This alternative would require the elimination of the 18 tracts estimated to be oil or oil and gas prone and would result in the loss to this proposed sale of the 100-200 million bbl. of estimated undiscovered recoverable reserves of oil.

Development of gas prone tracts only would still require seismic exploration, exploratory drilling, construction of permanent platforms and pipelines, production well drilling, workovers, maintenance and repair work with the attendant potential adverse environmental impacts as discussed in detail throughout this environmental statement for those activities. If this alternative is followed, the overall importance associated with these activities with regard to the environment would be essentially the same as it would be if all the proposed tracts were offered. However, the magnitude of potential impacts would be reduced and the cumulative impacts associated with quantities of waste water effluents and debris, and the numbers of platforms and pipelines required to develop only gas prone tracts, would be fewer.

Tracts could be deleted which are identified by the matrix analysis as having a maximal potential impact. Tracts that have an additive index of 1.44 to 2.00 for oil spills and structures are considered to have a high risk potential for environmental damage. Two tracts (54 and 57) are tentatively considered at this time to have high maximal environmental risk potential as defined in this impact statement (Summary Risk Analysis Section). Two of the tracts (56 and 57) have been identified as hazardous because they are located in areas of unstable bottom sediments. Deletion of these tracts would eliminate the risk of damage to a rig, an oil spill, or loss of life that might possibly occur as a result of this particular geologic hazard.

Acceptance of the alternative to delete all tracts identified as having a maximal potential impact would have the environmental effect of reducing the total number of platforms by approximately one to four, from this proposed sale. It would likewise incrementally reduce the discharges and disposal of waste water, drill cuttings and muds that are estimated to occur along with exploration, development and production. It is not possible at this time to determine what effect the deletion of these tracts would have on the estimated miles and number of pipelines required for this proposed sale, but acceptance of this alternative would probably have little effect on major lines to shore. However, it is possible that deletion of these tracts would eliminate a few (anywhere from one to ten) of the small flow lines that connect platforms with other platforms and eventually with major pipelines to shore. Acceptance of this alternative could eliminate the greatest degree of potential oil spill damage to marsh, estuarine, wildlife refuge and management areas.

Another alternative that would modify the proposed sale would be to offer only those tracts estimated to have a minimal potential impact to the environment. In the case of this sale this alternative would require the deletion of two tracts (54 and 57) which are considered to have a maximal potential impact to the environment and four tracts (3, 36, 55 and 56) which have a moderate potential impact. Removal of these six tracts from this proposed offering would not significantly reduce the estimated quantity of structures, drill cuttings and muds, produced waste water and activities expected to occur if this proposed sale proceeds. The potential hazard to critical resources and use activities of the area due to impact of oil spills would be either eliminated or greatly reduced because of the location of the minimal potential impact tracts to these resources and multiple-use areas. This alternative would allow for reoffering of deleted tracts at a later date following a determination as to the extent of reserves in the general area.

Substitute tracts

Tracts with relatively lower potential environmental risk could be substituted for those of higher potential risk. This would result in a reduc-

tion of potential environmental harm. It could also mean that, in the event a sale were held, anticipated production of oil and gas resources would not reach production levels deemed necessary or desirable from a sale in the proposed area.

Should it be determined that greater production potential should be sought than is indicated from substitution of a similar number of tracts of relatively lower potential environmental risk and relatively lower oil and gas resource potential, a relatively larger number of tracts would have to be substituted to achieve the production activities, and this could affect a relatively larger area, both offshore and onshore, than under the proposed action. It is possible that there would be more exploratory drilling, more platforms constructed, additional miles of pipelines required and a substantial increase in production activities with an attendant increase in potential adverse environmental impacts as discussed in detail throughout this environmental impact statement for these activities.

The remaining prospective tracts in the Gulf that would be available for substitution under the proposed action are, almost without exception, being considered for lease offering in the near future. Thus, a substitution of available alternate tracts might only delay, not eliminate, further leasing consideration of any tracts replaced by substituted tracts under the proposed action.

Withdraw the Sale

Another option is to cancel or greatly reduce the size of the proposed sale. This option would reduce future OCS oil and gas production and would thus necessitate reducing energy consumption [Table B-1) by reduced demand or supply shortfalls, or developing alternative energy sources, or some combination of the two.

This section briefly discusses the following alternatives:

1. Energy conservation
2. Conventional oil and gas supplied
3. Coal
4. Nuclear power
5. Oil shale
6. Hydroelectric power
7. Solar energy
8. Energy imports
   - Oil imports
   - Natural gas imports
   - Liquefied natural gas imports
9. Geothermal energy
10. Other energy sources
11. Combination of alternatives

The condensed information presented in the energy alternatives section of this environmental statement are based, unless otherwise noted, on the contract study ''Energy Alternatives: A Comparative Analysis by the Science and Public Policy Program of the University of Oklahoma''. Copies of this study are available for review in the New Orleans OCS office, and in BLM's Office of Public Affairs in Washington, D.C., and can be purchased for $7.45 from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (Stock Number 041-011-00015-4). This study should be considered as an integral part of the alternatives portion of this EIS.

Energy Conservation

Vigorous energy conservation is an alternative that warrants serious consideration. The Project Independence Report of the Federal Energy Administration claims that energy conservation alone can reduce energy demand growth by 0.7% - 1.2% depending on the world price of oil. Aside from these savings, it is now widely recognized that wasteful consumption habits impose social costs that can no longer be afforded such as pollution and an inequitable distribution of fuel.

The residential and commercial sectors of the economy are often characterized as inefficient energy consumers. Inadequate insulation, inefficient heating and cooling systems, poorly designed appliances and excessive lighting are often noticed in these sectors. Reductions in consumption beyond those induced by fuel price increases could require new standards on products and buildings, and/or subsidies and incentives. These incentives could impose standards for improved thermal efficiency in existing homes and offices and minimum thermal standards for new homes and offices.

Excessive consumption is also evident in the industrial sector where energy inefficient work schedules, poorly maintained equipment, use of equipment with extremely low heat transfer efficiencies, and failure to recycle heat and waste materials are all commonplace. Estimated energy savings of between 10% - 30% may be available in this sector of the economy.

Transportation of people and goods accounts for approximately 25% of nationwide energy use. Energy inefficiency in the transportation sector varies directly with automobile usage. Automo-

biles, which account for 90% of all passenger movement in the nation, use more than twice as much energy per passenger mile as buses. Moreover, the average car carries only 1.3 passengers. Using short and mid-term conservation measures such as consumer education, lower speed limits, rate and service improvements on public transit and rail freight transit, energy savings of 15% - 25% might be possible.

Other policies which would encourage fuel conservation in transportation could include standards for more efficient new automobiles and incentives to reduce the miles traveled. An important new development in the fuel economy area could be the modification of the standard internal combustion engine. Although such an engine is now in the advanced stages of development, further study by automotive engineers, industry, and concerned federal agencies is necessary before an acceptable engine may be improved.

Significant energy savings are clearly possible through accelerated conservation efforts. The Project Independence Report estimates that conservation alone could result in a 2.2 million barrel per day reduction in petroleum demand by 1985. These savings will be necessary in order to achieve the goals of energy self-sufficiency.

Environmental Impacts

The environmental impacts of a vigorous energy conservation program will be primarily beneficial. The exact nature and magnitude of these impacts will depend on whether there is a net reduction in energy use or whether the reduction is accomplished through technological change and substitutions. In the former case, the net impacts will simply be that there are fewer pollutants of all kinds released. As an example, the 2.2 million bbl./day savings by 1985 mentioned above would result in a diminishment of various pollutants by the following amounts (HUD Contract No. H2026R, "Research Evaluation of a System of Natural Air Conditioning").

CO - 4 lbs/1000 gals = 189 tons/day
Hydrocarbons - 3 lbs/1000 gals = 142 tons/day
Particulates - 23 lbs/1000 gals = 1088 tons/day
NO_x - 60 lbs/1000 gals = 2838 tons/day
SO_2 - 157 lbs/1000 gals = 7426 tons/day

If energy conservation is achieved by technological change or substitution, the net reductions will be those stated above, less the incremental pollutants from other sources, as well as any new pollutants which might arise from these other sources.

Conventional Oil and Gas Supplies

Large supplies of oil and gas still remain in the U.S. The U.S. Geological Survey estimates that both onshore and offshore, to a depth of 200 meters, crude oil measured reserves as of December 31, 1974, were 34.25 billion barrels, indicated reserves were 4.64 billion barrels, inferred reserves were 30 billion barrels, and undiscovered recoverable resources ranged from 50 billion barrels with a 95% probability to 127 billion barrels with a 5% probability.

Despite the magnitude of reserves, domestic oil production is likely to continue to decline. All of the twelve oil production forecasts discussed in the Project Independence Blueprint claimed that in the next few years, the U.S. petroleum production decline would continue. Most of these same forecasts predict increasing domestic production by the late 1970's, but only under the most favorable conditions in terms of prices, regulations and environmental constraints.

To substitute directly for the proposed sale, onshore oil production would have to increase by 35 to 120 thousand barrels a day and onshore gas production by 0.5 to 1.1 billion cubic feet a day.

Conventional gas supplies are also expected to decline. The development of new reserves required to meet gas demand will depend on continued development of onshore areas and of commercially viable nuclear stimulation or massive hydraulic fracturing in order to produce natural gas from low permeability reservoirs.

Environmental impacts of oil and gas development may include land subsidence; soil sterilization due to oil and brines, and waste materials released by blowouts, equipment failure, and humand error; disturbance of land by building roads and structures, and pollution of ground and surface water due to poor well construction and oil spills.

Coal

Coal is the most abundant energy resource in the United States. Coal deposits underlie nearly 460,000 square miles in 37 states, constitute one-quarter of the known world supply and account for 80% of our proven fuel reserves.

Replacement of the energy expected to be realized from the proposed sale, 11 to 27 million tons of coal per year would be necessary. Though domestic reserves of coal could easily provide this quantity, serious limitations to coal develop-

ment exist. Coal is often an imperfect substitute for oil or natural gas. In many other cases, coal use is restricted by government constraints; limited availability of low sulphur deposits; inadequate mining, conversion, and pollution abatement technology; and the adverse environmental impacts associated with coal extraction and electricity generation from coal. Coal production is also faced with mining labor problems and strict standards for coal mine safety.

As with other extractable hydrocarbons, the quantity of available coal is a function of coal's market price. Current increase in the market price for coal are making more of the resource base available for domestic consumption.

Public concern over dangerous underground mine conditions inspired the Federal Coal Mining Health and Safety Act of 1969. This legislation has improved underground mining conditions and has therefore reduced the hazards to coal miners. On the other hand, it has also increased the costs of underground coal mining and has given strip mining a competitive advantage over underground mining. Strip mining is far less hazardous to miners than underground mining and hence is subject to fewer of the provisions and regulations of this act.

New strict air quality regulations have diminished the attractiveness of coal. One-third of the domestic coal reserve does not meet the low-sulphur requirement. The two-thirds of this reserve that is environmentally acceptable is located mainly in the Rocky Mountain states and is generally of lower BTU value than eastern coals. The cost of transporting Rocky Mountain coal to population centers of the eastern or western United States adds significantly to its price, putting much of it at a competitive disadvantage with other energy sources.

Coal gasification and liquefaction

Technology for conversion of coal into gaseous and liquid hydrocarbons has been established for several decades and a number of relatively low-capacity commercial plants exist in various parts of the world. However, few cost-effective advanced technologies have advanced beyond the pilot plant stage.

Numerous problems remain before commercial development of synthetic fuels from coal can proceed. Specific technical problems must be solved. The cost-effectiveness of synthetic fuels from coal will depend on prices of other fuels, primarily that of oil and natural gas. Control of adverse environmental effects will increase the cost of producing synthetic fuels. Possible constraints on development include resource constraints: availability of skilled workers, raw materials (coal, water, steel), capital; and institutional constraints: governmental policies (energy resource leasing, coal mining regulations, permit procedures, etc.), and the willingness of industry to invest in development of new technologies.

Coal gasification is accomplished by reacting solid coal with steam, oxygen, air, hydrogen, or mixtures of these gases, to produce first a raw gas containing methane, carbon monoxide, hydrogen, carbon dioxide, steam, hydrogen sulfide, and ammonia in varying proportions depending upon the process. Then raw gas is processed to reduce or enhance certain characteristics of these constituents in order to prevent environmental pollution and to produce the type of gas needed for a particular use.

Gaseous fuels with low, intermediate or high energy content can be produced. Low and intermediate gases are produced in a two stage process involving preparation and gasification; a third process, upgrading, is required to produce high-Btu gas.

Among low-Btu gasification processes under development are: Lurgi, Koppers-Totzek (both in commercial use), Bureau of Mines Stirred Fixed Bed and Westinghouse Fluidized Bed. Among high-Btu gasification processes under development are: Lurgi high-Btu gasification process, HYGAS, BI-Gas, Synthane, CO_2 Acceptor.

Coal liquefaction

As with coal gasification, production of liquid fuels from coal requires either an addition of hydrogen or a removal of carbon from the compounds in the coal. Coal liquefaction can be viewed as a change in the carbon to hydrogen ratio that can be accomplished through one of three reactions: hydrogenation, pyrolysis or catalytic conversion. Of these, only the last is in commercial operation. Among liquefaction processes under development are: Synthoil, H-Coal, Solvent Refined Coal, Consol Synthetic Fuel, COED, TOSCOAL and Fisher-Tropsch.

The primary environmental impacts of coal begin with coal mining. Underground mining may cause land subsidence. Strip mining and open pit

mining disrupt large surface areas, causing destruction of the top soil, wildlife habitats and vegetation. Large volumes of mine wastes must be disposed. Water quality problems may arise from damage to the ground water regime, acid mine drainage, and increased runoff and sediment loads in streams. Stripping increases the dust content of the air. Combustion of coal, especially high sulphur coal, releases particulate and gaseous pollutants. Technology to effectively control the pollutants is not completely developed.

Nuclear Power

The predominant nuclear system used in the U.S. is the uranium dioxide fueled, light water moderated and cooled nuclear power plant. Research and development is being directed toward other types of reactors, notably the breeder reactor and fusion reactors.

As of March 31, 1975, fifty-three nuclear plants with a capacity of 35,000 MW were licensed to operate. At the end of 1974, nuclear power generated about eight percent of the Nation's electricity. However, about half of the electric power capacity now under construction is nuclear powered. Nuclear power development has encountered delays in licensing and siting, environmental constraints, and manufacturing and technical problems. Future capacity will be influenced by the availability of plant sites, plant licensing considerations, environmental factors, nuclear fuel costs, rate of development of the breeder and fusion reactors, and capital costs. In order to meet future uranium requirements, an increase in exploratory drilling activity will be necessary.

The nuclear capacity required to generate electricity to substitute for OCS sale production is shown below for two cases:

All of the OCS oil and gas were used to generate electricity.

All of the OCS oil and gas were devoted directly to end uses such as oil and gas heating.

The nuclear capacity required to substitute for the electricity which could be generated by the projected oil and gas from this proposed sale would be one to three 1,000-MW plants. The capacity required to substitute for end uses would be one to four 1,000-MW plants. The required amounts of nuclear fuel are shown in Table B-2 for both cases, assuming model 1000-MW light water reactors.

Although nuclear plants do not emit particulates or gaseous pollutants from combustion, the potential for serious environmental problems exists. Some radioactivity in the form of radiation, airborne radioactivity, and radioactive liquids is released into the environment. Although the amount released is very small and potential exposure has been shown to be less than the average level of natural radiation exposure, special precautions are required to control these emissions. The possible release of radioactivity as a result of an accident must be anticipated in the design of the plant and its emergency systems. Malfunction of the emergency core cooling system has been of particular concern.

Nuclear plants use essentially the same cooling process as fossil-fuel plants and thus share the problem of heat dissipation from cooling water. However, light-water reactors require larger amounts of cooling water and discharge greater amounts of waste heat to the water than comparably sized fossil-fuel plants. The effects of thermal discharges may be beneficial in some cases. Any adverse effects can be mitigated by use of cooling ponds or towers.

Low level radioactive wastes from normal operation of a nuclear plant must be collected, placed in protective containers, and shipped to an AEC storage site and buried. High level wastes created within the fuel elements remain there until the fuel is spent. They are then isolated in a fuel processing plant and stored in liquid or solid form at AEC storage facilities.

Primary residuals from light water reactors are waste heat and radioactive emissions.

For a 1000-MW plant operating at a 75% load factor, a 32% efficient nuclear plant would emit 47.6 x 10^{12} Btu's of waste heat annually. In comparison, a 38% efficient fossil-fuel plant would emit 36.5 x 10^{12} Btu's of waste heat. Annual radioactive emission for both types of light water reactors (boiling water reactor and pressurized water reactor) are given below.

Annual Radioactive Emissions

[For a 1,000 MW LWR]

Radioactive Gas	BWR (curies)	PWR (curies)
Tritium (H_3)	10	50
Iodine (I_{131})	0.3	0.8
Noble Gas (Krypton and Xenon)	50,000	7,000

Source: Teknekron, Inc., 1973, Fuel Cycles for Electrical Power Generation. Phase 1: Towards Comprehensive Standards: The Electric Power Case, for Office of Research and Monitoring, Environmental Protection Agency, Berkeley, California.

Oil Shale

The nation's vast oil shale resources have not been developed in the past because of the ready availability of low cost oil and gas. However, current needs have given impetus to oil shale development.

Oil shale can be processed in place (in-situ processing) or can be extracted using surface or underground mining and then processed on the surface.

The Green River Formation covering parts of Colorado, Utah, and Wyoming contains an estimated 600 billion barrels of oil shale, and represents the richest deposits in the U.S. An estimated 73% of oil shale lands, containing nearly 80% of the Green River Formation reserves, are federally held. The Department of the Interior, which manages these federal lands, has initiated a prototype oil shale leasing program to make these rich deposits available for development by private industry.

Oil shale development poses serious environmental problems. With surface or conventional underground mining, it is very difficult to dispose of the huge quantities of spent shale, which occupy a larger volume than before the oil was extracted. Inducing revegetation in an area of oil shale development is difficult and may take more than ten years. In-place processing avoids many of these environmental hazards. However, both methods could cause disturbance of underground aquifers and contaminations of ground waters.

Commercial development of the Green River Formation would require significant quantities of water in an area where water availability is already a problem.

The Green River Formation area is sparsely settled. Oil shale development would cause major changes in existing land uses and thus have social and economic repercussions in an area traditionally devoid of large scale industry. In addition, it would disturb wildlife; the Colorado oil shale lands have some of the largest migratory deer and elk herds in the world.

Roads, mining plant sites, waste disposal areas and utility line corridors would disrupt the land's vegetation cover and intensify sediment loads in the area's streams. Disposal of the huge volume of waste water containing dissolved inorganic and organic compounds without degrading natural ground waters would severely strain the region's already scarce water resources. Oil shale mining would raise noise pollution levels and the attendant particulate emissions would lower ambient air quality.

Hydroelectric Power

Hydropower is energy from falling water, which is used to drive turbines and thus produce electricity. Conventional hydroelectric developments convert the energy of regulated natural steam flows which fall from a height to produce electric power. Pumped storage projects generate electric power by releasing water from an upper to a lower storage pool and then the water is pumped back to the upper pool for repeated use. A pumped storage project consumes more energy than it generates but converts off-peak, low value energy to high value peak energy.

Many of the major hydroelectric sites operating today were developed in the early 1950's. Thirty to forty years ago, hydroelectric plants supplied as much as 30% of the electricity produced in the U.S. Although hydro plant production has steadily increased, thermal-electric plant production has increased at a faster rate.

As of May 1974, total conventional hydropower developed in the contiguous U.S. was 54,885 megawatts, nearly one half of which was located in the western states of Washington, Oregon and California. Some 6,878 megawatts of conventional hydro capacity are now being installed, about 90% of which is found in the western part of the country.

Much of recent hydroelectric development has been pumped storage capacity. As of May 1974, the total developed pumped storage capacity in the contiguous U.S. was 8,119 megawatts; capacity under construction was 6,253 megawatts. Over 30% of both developed capacity and capacity under construction is in the Middle Atlantic region.

The undeveloped potential for hydroelectric generation is about 93,000 megawatts in the lower 48 states and about 32,000 in Alaska. However, it is likely that hydroelectric power will represent a declining percentage of the total U.S. energy mix due to the following: high capital costs, seasonal variations in waterflow, land use conflicts, environmental effects, water use and flood control constraints. Sites with the greatest production capacity and lowest development costs have already been exploited.

Construction of a hydroelectric dam represents an irreversible commitment of the land resource beneath the dam and lake. Flooding eliminates wildlife habitat and prevents other uses such as agriculture, mining and free-flowing river recreation.

Hydroelectric projects do not consume fuel and do not cause air pollution. However, use of streams for power may displace recreation and other uses. Water released from reservoirs during summer months may change ambient water temperatures and lower the oxygen content of the river downstream, adversely affecting indigenous fish. Fluctuation reservoir releases during peak loak operation may also adversely affect fisheries and downstream recreation.

Fish may die from nitrogen supersaturation, which results at a dam when excess water escapes from the draining reservoir. High nitrogen levels in the Columbia and Snake rivers pose a threat to the salmon and steelhead resources of these rivers.

The quantity of hydroelectric energy needed to substitute for the oil and gas expected from the proposed sale depends on whether the oil and gas would be used directly for purposes such as heating or if it were burned to produce electricity, an indirect use. Since direct use is more efficient, substitution in this instance would require a larger quantity of hydroelectric energy in comparison with the case where oil and gas were used to produce electricity.

In order to substitute for end uses, 850-3,400 megawatts per day of hydroelectric energy would be needed. To substitute for the electricity which could be generated by the oil and gas, 656-2,600 megawatts of capacity would be needed.

However, hydroelectric power cannot be substituted for oil and gas in non-transportation users or in industrial uses that depend on the unique properties of oil and gas. Land use priorities often inhibit development. Furthermore, few dams are built solely for hydroelectric power generation. Irrigation, navigation, municipal and industrial uses, and flood control are frequently more important than and not fully compatible with power production needs. Since hydropower is most often used to service peak loads, other energy sources must be relied on for base power loads.

Solar Energy

Energy from the sun can be used to heat or cool individual buildings and to generate electricity. In the 1940's and 1950's prior to the availability of low cost natural gas, firms selling solar water heaters did a booming business in California and Florida. Commercially installed solar heating and cooling in homes will be in use in many parts of the nation by 1985 and will be more common by 1993. Moreover, intensifying current research and development could hasten these dates by five years (Morrow, 1973). Solar energy will eventually supply 35% to 50% of the nearly 20% of the nation's energy that is now devoted to space conditioning, thus reducing significantly the peak electricity demands of the summer months.

Applications of solar energy must take into account the following: (a) Solar energy is a diffuse, low intensity source, (b) its intensity is continuously variable with the time of day, weather and season, and (c) its availability differs widely between geographic areas.

Potential applications of solar energy show a wide range. Among them are:

Thermal energy for buildings
Water heating, space heating, space cooling, combined systems
Renewable clean fuel sources
Combustion of organic matter
Bioconversion of organic materials to methane
Pyrolysis of organic materials to gas, liquid and solid fuels
Chemical reduction of organic materials to oil
Electric power generation
Thermal conversion
Photovoltaic - residential/commercial, ground central station, space central station
Wind energy conversion
Ocean thermal difference

Because of the energy situation, congressional interest in solar energy research has intensified. The Solar Heating and Cooling Demonstration Act of 1974 legislates a $60 million demonstration program aimed at proving the commercial feasibility of solar heating $5,000-$6,000 (including costs of a standby conventional furnace) compared to $1,000-$2,000 for a conventional fossil-fuel home heating unit. However, the rising cost of gas and oil needed by the conventional heaters means that the initial difference in fixed costs will quickly be overshadowed by the solar systems' lack of fuel costs. Therefore, though more costly at first, the solar unit will be the economical alternative over time.

Additionally, technological change could reduce cost. For instance, one demonstrated direct use of

solar energy to heat and cool individual buildings appears to be very successful according to a recently completed study. This study called "Research Evaluation of a System of Natural Air Conditioning" was completed by a professional group from California Polytechnic State University under contract to the Department of Housing and Urban Development (Contract No. H2026R). In part this report states: "Results have shown that this system with minor modifications discovered by this evaluation, is workable from an architectural, a thermal, an economic, and occupancy standpoint at the present time, and that this system could play an important role in energy conservation in the United States without further prototype development."

What is particularly significant about this scientific report is that it was completed on an occupied California home (Atascadero). It needed no backup system and furthermore used no oil, gas or electricity for heating or cooling throughout a year in which outside temperature ranged from 20° to 99° F. During this period the report states that the indoor temperature at the five foot level cycled less than 4° F daily and the system ("Skytherm" Systems were invented and patented by Harold R. Hay of Los Angeles, California) was able to keep the indoor temperature between the extremes of 66° F and 74° F except during special test periods or times of prototype breakdown.

Another excerpt from this report states: "Assuming that the system can be built with no premium, a 1,500 sq. ft. house costing $30,000 on a $6,000 lot carrying an eight percent mortgage of $28,000 on which $20.00/month of utility cost saved is applied as additional payment, would have its loan period reduced from 25 to 19.7 years with an interest savings of about $13,600. If a $30/month utility reinvestment is made possible, the interest saving is about $17,500.

With this system's "zero" energy consumption, compared to conventional heating and cooling costs, it is appropriate to calculate the saving in fuel consumption at the point of electricity generation. Production of one KWHR of electricity requires about 13,656 BTU (assuming a 25% rate of efficiency in production and transmission). If one barrel of fuel oil (42 gallons) can produce 6,250,000 BTU then Skytherm in Atascadero is conserving approximately 20 barrels of fuel for annual heating and approximately an additional 10 barrels of fuel for cooling equaling an annual total savings of about 30 barrels.

The faster solar-conditioned houses are added to the housing inventory the greater their input on the total energy consumption for the United States. If, for instance, over a period of 40 years, Skytherm type houses are built at an average rate of 50,000 units per year, the 2 million units will represent 2% of a 100 million total at the end of that period. To the extent that residential use continues to represent about 40% of the national energy consumption, the saving attributable to these type houses would be 0.8% of the national total.

In terms of air pollution, a saving of 1,500,000 (assuming one years construction of 50,000 homes at a savings of 30 barrels per year) barrels (63,000,000 gallons) annually, would cause a reduction in air contaminants (the reduction varies according to the grade of fuel being burned) (Table B-3).

Presently this system has only been proved (according to the report) for the Southwest but other "Skytherm" Systems have been conceived for other climates and are in the early development stages.

Other new developments have been undertaken in the State of Colorado with rapid growth in solar homes and office buildings. On the outskirts of Colorado Springs a 30 million dollar hospital complex is being built and will have a 1 million dollar solar heating system. The initial outlay is high but a city official feels that the savings in fuel over a six year period should pay for the system (U.S. News and World Report, June 2, 1975). The city is also requesting Federal financial assistance to install a single central bank of solar collectors to heat 54 low income homes.

The full potential of solar energy can be realized only after large-scale generation of electricity using solar energy becomes technically and economically feasible. In this regard, the Ford Administration has requested $33 million for solar electricity programs in fiscal 1975 - almost $26 million more than the fiscal 1974 appropriation. A number of technical and engineering problems now prevent commercialization of solar steam-electric plants though pilot projects are well underway. It is estimated that solar electricity will be available on a significant scale in 10-15 years. (As a comparison, peak production from this proposed sale will occur five years after leases have been issued).

Solar energy does have a few disadvantages including high capital costs, expensive maintenance on solar collectors, thermal waste disposal, and distortion of local thermal balances being some of the most prominent aspects.

The accelerating real costs of fossil-fuel will continue to increase the attractiveness of the solar energy option. In addition, the environmental impacts of solar energy are relatively less severe than those imposed by the traditional energy sources.

Solar energy cannot substitute for petroleum in all uses, transportation and petrochemicals being the most evident examples. However, as solar energy is used with increasing frequency for heating and electricity generation, oil and gas supplies previously devoted to heating and electricity will be channelled to the petrochemical and transportation industries and other exclusive uses of oil and gas.

Energy Imports

Oil Imports

The United States' reliance on imported oil has increased steadily in the last decade. Competition on the world market and cutbacks in Middle Eastern oil exports have raised questions about the availability of oil imports in the future. Declining resource availability and increasing domestic demand restrict potential imports from the Western Hemisphere, particularly Latin America. Increasing imports from the Middle East bring problems of security of supply, balance of payments, U.S. off loading capacity and refinery capacity.

During November 1975, imports of crude oil into the United States amounted to 4.6 millions of barrels per day (FEA, January 1976). The average refiner acquisition cost of imported crude petroleum was $14.66 per barrel during October 1975, indicating a total expenditure for crude oil imports of approximately $67.5 million dollars per day. The crude oil production from this proposed sale is estimated to amount to 30,000 barrels per day, which valued at the average price of $14.66 per barrel, indicates a value of approximately $440 thousands of dollars per day. This amount is an estimate of the current cost of replacing the crude oil production anticipated from this proposed sale with imported crude oil.

Increasing petroleum imports in lieu of OCS development would be contrary to U.S. goals of greater energy self-sufficiency.

The primary environmental hazard of increased oil imports is the possibility of oil spills which can result from intentional discharge, accidental discharge and tanker casualties. Intentional discharges would result largely from tank cleaning operations. The effects of chronic low-level pollution are largely unknown. The worldwide tanker casualty analysis indicates that, overall, an insignificant amount of the total volume of transported oil is spilled due to tanker accidents. However, a single incident such as the breakup of the Torrey Canyon can have disastrous results. With increasing tanker traffic in already crowded harbors, the probability that such an incident could occur is increased.

Natural Gas Imports

During November 1975, imported natural gas amounted to an estimated 80 billion cubic feet, approximately five percent of the total U.S. marketed production of 1,600 billion cubic feet. During 1973, the United States imported natural gas from Canada, Mexico and Algeria.

During September 1975, the average price of natural gas paid by major interstate pipeline companies from domestic producers were 36.5 cents per thousand cubic feet, compared to a price of 141.2 cents per thousand cubic feet paid by Canadian and Mexican sources. The gas production estimated to result from this proposed sale amounts to 360,000 mcf per day. Substitution of imported gas for this volume of production would cost approximately $508 thousand dollars per day.

The environmental impacts of increasing gas imports are derived mainly from the possible increased use of land for pipeline construction and a further possible impact is the risk of explosions and fires.

It is uncertain whether increased quantities of natural gas will be available for import from either Canada or Mexico. Canada has intentions to gradually phase out oil exports to the U.S. which also raises questions regarding their intentions toward natural gas pipeline exports.

Liquefied Natural Gas Imports

The growing shortage of domestic natural gas has encouraged projects to import liquefied natural gas (LNG) under long term contract. Several LNG projects are now under consideration on the Pacific, Atlantic and Gulf coasts. However, the Middle East oil cutback has raised questions concerning the security of foreign LNG. The com-

plexity and length of time involved in implementing these proposals has been increased by the need for negotiating preliminary contracts, securing the approval of the Federal Power Commission and the exporting country, and making adequate provision for environmental and safety concerns in the proposed U.S. facilities.

The environmental impacts of LNG imports arise from tankers; terminal, transfer and regasification facilities; and transportation of the gas. The primary hazard of handling LNG is the possibility of a fire or explosion during transportation, transfer or storage.

Receiving and regasification facilities will require prime shoreline locations and dredging of channels. Regasification of LNG will release few pollutants to the air or water.

LNG imports will influence the U.S. balance of payments. This impact will depend on the origin and purchase price of LNG, the source of the capital, and the country (U.S. or foreign) in which equipment is purchased and LNG tankers are built.

Replacement of the estimated oil and gas production from the proposed sale would entail importing the equivalent of 131-525 million cf per day.

Geothermal Energy

Geothermal energy is primarily heat energy from the interior of the earth. It may be generated by either radioactive decay of elements such as uranium or thorium or friction due to tidal and crustal plate motions.

There are four major types of geothermal systems: hot water, vapor dominated, geopressured reservoirs and hot dry rock systems.

Geothermal plants are smaller than conventional plants and require a greater amount of steam to generate the same amount of electricity. This is due to the fact that temperatures and pressures associated with geothermal areas are lower than those created at conventional power plants.

The greatest potential for geothermal energy in the U.S. is in the Rocky Mountain and Pacific regions; some potential exists in the Gulf Coastal Plains of Texas and Louisiana. The Geysers field in California is the most extensively developed source of geothermal energy in the United States and it has been producing power since 1960. Exploration efforts are also underway in the Imperial Valley, Salton Sea, Mono Lake and Modoc County, Calif.

Within 20 years, geothermal energy may account for about one to two percent of total U.S. energy and about five percent of California's total energy consumption.

In order to substitute for end uses of the estimated oil and gas from the proposed sale, 850-3,400 megawatts of geothermal capacity would be needed. To substitute for the electricity which could be generated by the estimated oil and gas, 656-2,600 megawatts of capacity would be needed.

A number of gases are associated with geothermal systems and may pose health and pollution problems. These gases include ammonia, boric acid, carbon dioxide, carbon monoxide, hydrogen sulfide and others. However, adverse air quality impacts are generally less than those impacts associated with sulfide-fuel plants. In addition, saline waters associated with geothermal energy systems must be disposed of and isolated from contact with ground water regimes. Land quality problems stem from disturbance due to the construction of related facilities. Possible ground subsidence, which in turn can cause structural failures and loss of ground water storage capacity, is an additional impact which could occur as a result of utilization of geothermal energy systems.

Other Energy Sources

The high costs and rapidly shrinking reserves of the traditional energy fuels have encouraged research into new and different sources for potential energy. Some of these alternate sources have been known for decades but high costs and technical problems have prevented their widespread use.

Environmental impacts of these alternatives are difficult to assess, especially if a great amount of research and development remains to be completed before operational scale systems can be developed, tested and evaluated for production and application.

For the alternatives set forth on Tables B-3 and B-4, the date of commercial availability will depend on the cost of the traditional energy fuels, the level of federally-subsidized research, and the solution of engineering and technical problems. (Tables B-1 and B-2.)

Federal energy research development funding has expanded significantly in the last few years. Tables B-4 and B-5 show funds for different areas of research.

Combination of Alternatives

In the interest of clarity of presentation, each alternative form of energy has been discussed separately. However, it is likely that each of these alternatives will be developed to a lesser or greater degree, depending on such variables as the direction and pace of technological development, the identification of undiscovered resources, the rate of national economic growth and the change in lifestyles. The extent to which alternative sources may replace or complement offshore oil and gas is related to the total national energy system. Relevant factors are: Historical relationships indicate that energy requirements will grow at about the same rate as gross national product. Energy requirements can be constrained to some degree through price mechanisms. Other factors such as capital investment may be substituted for energy, for example, insulating to reduce heating/cooling expense. Lower energy use can be effected through rationing, altered transportation modes and major changes in lifestyles. Energy sources are not completely interchangeable. For example solid fuels cannot be used directly in internal combustion engines. Fuel conversion potentials are limited in the short term and are somewhat more flexible in the long term, when choices in energy-consuming capital goods are made. Research and development effort is being directed to energy conversion: more efficient nuclear reactors, coal gasification and liquefaction, oil shale extraction and others. Several of these could assume important roles in the future energy supply, although their future competitive relationship is still uncertain. Major potentials for filling the supply/demand imbalance are: energy conservation, environmentally acceptable systems using domestic coals, accelerated exploration and development of domestic oil and gas resources and development of oil shale. Oil and gas imports entail: security risks related to the reliance for essential energy supplies on sources which are politically unstable and which may interrupt supplies to exert political and economic pressure, aggravation of unfavorable international trade and payment balances, high costs of liquefying and transporting natural gas other than by pipeline over land.

TABLE B-1.—*Energy needed from other sources to replace the expected oil and gas production from the proposed OCS sale No. 44.*

	Billion Btu/day
1. *Btu equivalents:*[1]	
Oil—7,500–30,000 bbl/day	42–168
Gas—90,000–360,000 thous. cu. ft./day	92–368
Total	134–536
2. *Oil equivalents:*	*Bbl/day*
Oil from other sources needed to directly replace expected oil production	7,500–30,000
Oil from other sources needed to replace expected gas production	16,400–65,600
Total	23,900–95,600
3. *Gas equivalents:*	*MMcf/d*
Gas from other sources needed to replace expected oil production	41–165
Gas from other sources needed to directly replace expected gas production	500–360
Total	131–525
4. *Coal equivalent:*	*Thousand short tons/day* 5.6–22.3
5. *Electrical equivalents:*	*Thousands of megawatts of capacity*
Substitute for end uses[2]	850–3,400
Substitute as input to electricity generation[3]	656–2,600

[1] Conversion factors used:
1 barrel of oil = 5.6×10^6 Btu.
1 cubic foot of natural gas = 1,021 Btu.
1 ton of coal = 24×10^6 Btu.
1 kilowatt hour = 3,412 Btu at the theoretical conversion rate of other energy forms to electricity at 100 percent efficiency.

[2] Based on a 65 percent average efficiency of end use of oil and gas (such as oil and gas heating) and a plant load factor of 80 percent.

[3] Efficiency of fossil fuel electricity generation was assumed to be 40 percent. Efficiency of present fossil fuel generation averages about 33 percent.

Table B-2—*Nuclear capacity required to Generate Electricity to substitute for OCS sale 44.*

	1 to 3 1,000-MW light water reactors	1 to 4 1,000-MW light water reactors
(1) Tons U238 first core fuels first year only [1]		
first year only [1]	580-1,740	580-2,320
(2) Thousands of tons of uranium ore required for (1) [2]	290-870	290-1,160
(This comparison has several limitations, among them the difference in lifetime between an OCS oil and gas field (15-20 years) and a nuclear powerplant.)		
(3) Tons U238 annual reloads without plutonium recycling	200-600	200-800
(4) Thousands of tons of oranium ore required for (3)	100-300	100-400
(5) Tons U308 annual reload with plutonium recycling	175-525	175-700
(6) Thousands of tons of oranium ore required for (5)	87.5-263	87.5-350
(7) Acres of land required for sites only [1]	1,000-3,000	1,000-4,000
(8) Cubic feet of high level solid wastes produced yearly	75-225	75-300
(Assuming a normalized 1,000 acres per 1,000 MW light water reactor. Of this, 12 acres per year is non-reclaimable.)		

[1] Assuming 80 percent plant factor.
[2] Assuming 0.20 percent average ore grade.

TABLE B-3

Energy Alternatives and Federal Energy Research Development Administration Funding (in millions).

Program area	1974		1975		1976		T.Q.	
	BA	BO	BA	BO	BA	BO	BA	BO
Conservation:	25.4	8.6	45.5	31.8	64.1	58.4	14.7	12.7
End use					5.0	3.0	1.0	1.0
Transmission	3.0	1.5	12.6	6.6	13.8	13.1	2.5	2.8
Conversion	10.9	3.8	21.4	14.7	25.0	24.4	6.5	4.5
Storage	1.7	1.5	6.6	5.6	10.1	9.0	2.0	2.1
Automotive	9.8	1.8	4.9	4.9	10.2	8.9	2.6	2.3
Oil, Gas, and Shale:	11.8	11.3	33.1	21.2	36.0	32.5	9.7	9.8
Oil and Gas	3.1	2.6	23.7	13.6	23.9	21.0	5.9	6.2
Oil shale	3.3	2.8	5.1	2.5	9.4	8.4	2.4	2.4
Related programs	5.1	6.0	4.0	3.7	2.4	2.7	1.4	1.1
Trust funds	.2	-.1	.3	.4	.3	.4	.1	.1
Coal:	134.5	69.9	296.3	186.3	346.8	293.2	93.9	51.0
Combustion	15.5	3.5	35.9	20.7	38.1	32.6	14.8	5.1
Liquefaction	46.3	19.8	107.7	57.6	97.6	96.9	28.8	16.0
Gasification-Hi BTU	33.3	29.4	64.4	62.4	63.4	42.8	10.5	8.7
Gasification-Low BTU	22.1	8.4	52.0	17.8	45.4	51.7	11.4	6.5
Demo program					57.0	27.1	17.0	7.6
Other	9.9	1.5	23.3	14.8	35.4	32.1	8.9	4.6
Trust funds	7.3	7.3	13.0	13.0	10.0	10.0	2.5	2.5
Environmental control (thermal pollution)	0.2	0.2	2.3	1.8	4.9	4.1	1.4	1.2

Table B-3 (continued) Energy Alternatives and Other Federal

Program area	1974		1975		1976		T.Q.	
	BA	BO	BA	BO	BA	BO	BA	BO
Fisson:	503.3	483.2	697.3	618.2	770.5	681.1	177.9	210.9
LMFBR	363.2	353.6	497.2	447.5	544.0	470.0	117.2	137.2
Other breeders	2.5	3.6	13.7	9.8	11.6	12.4	3.0	3.1
HIGR	14.9	13.1	39.0	23.1	35.0	36.6	8.8	9.8
LWBR	31.6	28.3	36.9	35.7	35.1	37.9	11.1	9.4
Waste management	10.8	7.8	16.0	14.2	22.4	20.9	6.7	5.9
Uranium enrichment	64.9	63.1	72.3	73.4	74.2	78.7	22.3	20.6
Other	15.4	13.7	22.2	14.5	48.2	24.6	8.8	24.9
Fusion	112.2	99.0	179.6	146.7	225.5	214.0	72.0	60.0
Solar, geothermal, others	18.7	11.5	71.0	26.8	101.6	92.6	27.8	19.5
Solar	7.9	4.0	38.4	8.8	70.3	57.1	20.7	14.8
Geothermal	9.4	6.4	28.1	14.5	23.4	28.9	5.2	3.2
Systems studies	1.1	.9	3.9	3.0	7.3	6.0	1.6	1.3
Miscellaneous	.3	.2	.6	.5	.6	.6	.3	.2
TOTAL DIRECT	806.1	683.7	1325.1	1032.8	1549.4	1375.9	397.4	365.1
Environmental effects	88.5	88.1	139.9	115.0	146.1	140.9	36.6	36.5
Basic research	114.7	115.6	143.0	135.1	152.0	144.9	41.6	38.6
Total supporting	203.2	203.7	282.9	250.1	293.1	285.8	78.2	75.1

(BA) Budget authority; (TQ) Transition quarter; (BO) Budget outlays.
Source: U.S. Office of Management and Budget, 1976 budget special analysis.

TABLE B-4 Energy Alternatives and Other Federal Energy Research Development Funding (in millions)

Program area: agency	1974		1975		1976		T.Q.	
	BA	BO	BA	BO	BA	BO	BA	BO
Conservation:	20.7	18.0	32.4	22.5	23.7	24.4	5.3	5.1
End use:								
DOC	4.2	3.9	2.9	3.1	2.7	2.6	.6	.6
Transmission:								
NSF	1.7	1.2	1.2	.7		1.0		
Conversion:								
NSF	1.2	1.1	4.5	2.0	2.0	2.0	.3	.3
NASA	.4	.4	.4	.4	.4	.4	.1	
Storage:								
NSF	1.9	1.6	7.5	3.0	2.0	1.7	.3	.2
DOI			.3	.3	.3	.3	.1	.1
Automotive:								
NSF	.9	.6	.9	.5	1.0	1.0	.3	.3
DOT	2.2	1.4	6.5	4.5	7.0	7.0	1.7	1.7
NASA	1.9	1.9	.9	.9	1.0	1.0		
DOD	3.9	3.9	5.1	5.1	5.1	5.0	1.3	1.3
EPA	2.4	2.0	2.2	2.0	2.2	2.2	.6	.6
Oil, gas, shale:	.3	.3	6.4	7.3	6.6	5.3	1.6	1.6
Oil and gas:								
NSF	.1	.1	.3	.1	.5	.3	.1	.1
Oil shale:								
DOI			5.6	6.9	5.6	4.6	1.4	1.4
NSF			.3	.1	.3	.2	.1	.1
Related:								
DOC	.2	.2	.2	.2	.2	.2		

Program area: agency	1974 BA	1974 BO	1975 BA	1975 BO	1976 BA	1976 BO	T.Q. BA	T.Q. BO
Coal:	8.4	8.2	49.8	37.8	49.4	49.2	13.2	14.4
Mining: DOI	7.5	7.5	42.2	31.3	42.2	42.2	11.8	12.8
Direct combustion: NSF			1.2	.9	1.0	.9	.2	.3
Liquefaction: NSF	.3	.2	.9	.6	.8	.8	.2	.2
Gasification-Hi: DOC	.2	.2	.2	.2	.2	.2		
Gasification-Lo: NSF	.3	.2	.9	.6	.8	.7	.2	.2
Other: AGRI			3.8	3.8	3.8	3.8	.7	.7
NSF	.1	.1	.6	.4	.6	.6	.1	.2
Environment:	65.6	58.1	101.0	34.0	78.0	90.0	22.1	25.1
EPA	65.5	58.0	99.0	32.0	73.0	85.0	22.0	25.0
DOI	.1	.1	2.0	2.0	5.0	5.0	.0	.1
Fission:	48.6	47.1	64.9	60.2	106.4	95.5	24.5	23.6
LMPBR: DOC	1.0	1.0	1.0	1.0	1.0	1.0	.2	.2
Other: DOI			1.1	1.1	1.1	1.1	.2	.2
Safety: NRC	47.6	46.1	62.8	58.1	104.3	93.4	24.1	23.2

Delay the Proposed Sale

Until New Equipment is Available to Provide Increased Environmental Protection

This alternative considers delaying the proposed sale pending the development of new oil spill containment and cleanup equipment. Present equipment is considered adequate for the Gulf of Mexico.

A summary of oil spill containment equipment (USDI, 1975b, Vol. 2, Appendix C) illustrates the capability limits of existing equipment in cleanup operations under conditions of rough water. Most existing oil spill equipment becomes unusable and inefficient when waves exceed 1.2 to 1.8 meters in height and in some cases will not hold together when waves exceed 2.4 meters (Leary, 1975).

Summary of Equipment

Modular weir skimmer: In this operation, oil floating on the surface flows by the action of gravity over an edge, into a sump region and into a storage facility. This operation depends on gravity and would seem of very limited value in turbulent waters.

Rotating disc skimmers: The rotating disc skimmer rotates about an axis parallel to the water surface, where it encounters the oil layer. A film of oil clings to the disc surface as it continues along its path through the water, with a wiper assembly removing the oil. This procedure is susceptible to interference by high waves. An indication of specific wave height is not given although mathematical formulation for an estimation is projected.

Oleophilic belt skimmers: This instrument consists of a belt which passes through the water first, then absorbs the oil as it passes through a slick. The oil is conveyed to a wringing device for recycling. "Two or more rotating filter-type belts are installed between the catamaran hulls of the self-propelled skimmer craft. Developed by a large corporation, the belt allows water to flow freely through, but captures and removes the oil and oily debris from the surface of the ocean. It is particularly effective in large waves as the force of the waves enhances the skimming action rather than hinders it." (Smith, 1975)

The above author suggests that in waves above 2.4 meters, the skimmer craft will probably not be used. The force of waves in seas of greater turbulence is enough to disperse oil to such an extent that it is not possible to use mechanical means to

retrieve the oil, despite the ability of a skimmer to function with reduced efficiency. However, oil dispersed into the water column as a result creates a toxic hazard to offshore fauna and flora.

A series of tests by Leary (1975) on at least three developing methods of high seas oil retrieval gave varied results. The three methods: free vortex, disc drum and weir basin, were required to meet three criteria for high seas testing: to be air transportable in a C-130 aircraft; to recover oil at a maximum rate of 2000 gpm; and to operate on the high seas in a Sea State 4 with winds of 20 knots and a current of 2 knots. However, the system need not operate in a Sea State 6 (Sea State 6 refers to a severe weather condition with winds of 40 knots). A summary of the results of testing in these three high seas devices follows:

Weir basin: The weir basin 2000 gpm system (that is weir basin with a recovery goal of 2000 gpm per unit) can be transported by a Coast Guard C-130 aircraft to the point of the spill. The instrument can recover oil approximately one-half inch thick when towed at a one knot current speed. Wave heights during laboratory testing measured 0.6 meters. However, only a reduced model, the W-B 1000 gpm, is currently able to withstand Sea State 6 environment and recovery is not possible at that time. A W-B 2000 gpm cannot withstand high seas at Sea State 6 at this time.

According to Leary's (1975) testing, ". . . with further development, the weir basin system could possibly prove to be a useful device on the high seas especially when towed in a sweeping mode so that a relative current (of two knots) is achieved."

Disc drum: The disc drum is a prototype device which has been subjected to high seas testing on the west coast of the U.S. during the early summer, fall and winter of 1973 and early 1974. According to Leary (1975), the tests were for the purposes of examining the system for "structural capability, handleability, seakeeping capability and operational characteristics."

The disc drum was able to recover oil between 0.25 and 2.5 centimeters thick with speeds between one-half and three knots and with three different oils ranging from 8CS to 1000CS. The disc drum has proven sensitive to viscosity and relative current speed in terms of recovery rate. The high seas testing showed very convincingly the reliability of operation and superior handleability of the disc drum system (Leary, 1975).

Free vortex: The free vortex is still undergoing research and development but it is anticipated as a high seas oil recovery device.

The effects of water motion on spilled oil has been studied by Leibovick (1975). Some comments from his work are cited prior to the discussion on equipment. From his comments, it will be seen that with greater water movement, oil removal becomes more difficult and eventually impossible despite the strength of operating equipment. "Oil spill removal and control in open water is seldom conducted in 'calm conditions, so the effects of waves and turbulence on the performance of oil spill equipment must be faced . . ." ". . . In addition to wave orbital speed and acceleration effects on skimming action, other effects of waves and water turbulence are: "The combined action of wave breaking and turbulence can cause floating oil films to disintegrate and become mixed into the water column as droplets. The extent and importance of mixing depends upon oil type and the vigor of turbulence and wave breaking. Once oil is removed from the surface by natural means in large amounts, containment and cleanup operations are pointless. "Reflections and focusing of short waves is a striking occurrence in containment booms. These effects are analyzed in this paper. Losses due to splash-over can result, and enhance turbulence in the containment region can occur due to wave breaking. Turbulence can lean, as in the previous item, to loss of oil into the water column. With many oils, the addition of mixing energy due to increased wave breaking has the opposite effect of creating a water-in-oil emulsion. Such emulsions have viscosities that are orders of magnitude greater than that of the oil alone, and this leads to dramatic reduction in the pumping rates of removal and transfer equipment. "Observations in wave tanks clearly show that oil thickens in wave crests and is thinned out in the throughs. This is a possible mechanism by which oil films may be broken into patches. A theoretical explanation for this phenomenon is given here. One consequence for oil spill containment is that, since there is relatively more oil in wave crests, splash-over losses are larger than would be expected if the oil thickness was nearly uniform . . ."

The Department of the Interior has made many changes in its procedures since the 1969 Santa Barbara oil spill, and since receiving and acting on recommendations received in 1974 from the Council on Environmental Quality and others. U.S. Geological Survey has made revisions to the OCS operating orders and regulations (Appendix B), offshore inspections have been expanded and the offshore effluent limitation guidelines promulgated by EPA have been incorporated into the OCS operating orders. Additional participation has been solicited from both Federal and State agencies for input into the environmental impact statement prepared for each lease sale.

Pending Completion of Studies in the Gulf of Mexico Concerning the Potential Environmental Impacts of Offshore Minerals Development

The proposed sale could be delayed pending completion of all environmental baseline and other special studies in the Gulf of Mexico proposed sale area. The objectives of the Bureau of Land Management's OCS environmental studies program are as follows:

Provide information about the OCS environment that will enable the Department and the Bureau to make better management decisions regarding the development of mineral resources.

Basis for predicting impact of oil and gas exploration and development on the marine environment.

Establish a basis for prediction of impact of OCS oil and gas activities in frontier areas.

Provide impact data that would result in modification of leasing regulations, operating regulations, or operating orders.

The BLM environmental studies effort in the Gulf of Mexico was initiated in May, 1974, with the MAFLA Environmental Baseline Study, and in October 1974 with the South Texas Baseline Study. These studies consist of collecting baseline data for physical and chemical oceanography, geology, plankton, and benthos, and establishing background levels of trace metals and hydrocarbons in sediments, water and biota.

The MAFLA Baseline Study was completed in March, 1975 and the MAFLA Monitoring Study has been initiated. The latter study has not completed all sampling. A final report will be available about December, 1976.

In the South Texas Baseline Study, the separate element (Geology, Biology and Chemistry and Historical Fisheries and Physical Oceanography) reported are complete. The final integrated report will be available in July, 1976. The second-year studies in south Texas began in January, 1976. These will include site-specific monitoring.

In subsequent years, the primary effort of the environmental studies program will be oriented towards baseline and site-specific monitoring. The effort of these programs will be contingent upon the intensity of oil and gas exploration and development activities within the Gulf of Mexico OCS.

This proposed sale could not be held earlier than October, 1976. By October, 1976, the environmental studies program will have been in effect in the Gulf of Mexico for over two years.

The information obtained from the completion of these studies has provided a greater degree of confidence than previously existed concerning the leasing of any given OCS area and the siting of offshore facilities, including pipelines, in relation to geologic, oceanographic, and biotic parameters. The distribution, numbers and seasonal variations of species is useful information not only in the siting of offshore facilities but in determining pipeline routes and burial requirements, and in tract-by-tract evaluations concerning potential environmental impacts from offshore operations. Further information from these studies could prompt deletion of a tract or tracts prior to holding the sale based on unacceptable potential environmental risk.

Information obtained thus far from the environmental studies program has provided information for the formulation of possible stipulations which could provide additional protection of environmental values within the proposed sale area.

Pending Development of Coastal Zone and Growth Plans Onshore

The proposed sale could be delayed pending the development of coastal zone management and growth plans onshore. Delay of the sale awaiting such plans could result in a greater degree of coordinated planning between the States bordering the Gulf of Mexico and the federal government.

The Coastal Zone Management Act, by which most states are substantially financing their planning, allows the States 3 years, or until 1977 (and possibly until 1978), to develop plans.

It is expected that the coastal zone plan will be relatively flexible, tending toward guidelines rather than "locked in concrete," highly specific

zoning ordinances. The onshore facilities that directly affect the state's coastal zone are pipelines, support and staging facilities. Support facilities can be and usually are constructed immediately proceeding a sale or when exploratory drilling commences. Pipelines, pipeline terminals and petroleum storage facilities, and possibly additional support facilities are built after petroleum is discovered, usually 1 to 5 years after a lease sale. These facilities are site-oriented and their location will be determined by the companies and approved by relevant state and local governmental authorities.

Finally, it should be noted that until this proposed sale is held, and until oil and gas are discovered, the size or location of needed facilities cannot be specifically identified by industry. It is expected that facility siting will be decided in accordance with applicable state and local regulations, and if in existence, within the framework of a state coastal zone plan.

Pending Completed Implementation of Recommendations made in Reports on OCS Operating Orders and Regulations and a Review of Regulations and Amendments as Necessary

A decision could be made to delay this proposed sale until implementation of those recommendations made in reports concerning strengthening operating procedures has been completed. During the implementation of these recommendations, a review could be completed of all operating and leasing regulations, OCS orders and statutory provisions to locate sections or areas of needed revision. Any necessary amendments of the regulations and orders could be made through the appropriate procedures and, if sections of the OCS Act were found to need revision, amendments could be suggested to Congress. In considering this alternative, the existing authority of the OCS Act to prescribe and amend regulations any time the Secretary determines it to be necessary and proper so as to provide for the prevention of waste and conservation of the natural resources of the outer continental shelf and the protection of correlative rights therein, must be kept in mind (43 U.S.C. §1334 (a)(1). Any revisions of the operating regulations or the OCS orders which relate to the prevention of waste, conservation of natural resources, or protection of correlative rights, could be made at any time and apply to all existing leases.

Alternatives Within the Proposed Action

Government Exploratory Drilling Prior to Leasing

Exploratory drilling conducted by or sponsored by the federal government prior to holding a lease sale would be an alternative within the proposed action. This would involve an alternative approach to one aspect of the present federal leasing system. At the present time, there is little exploratory drilling on the OCS prior to leasing. The United States Geological Survey receives all engineering and geologic data from companies who have drilled on leases issued on the OCS.

These data and geophysical data purchased on the open market are used by the Geological Survey to develop OCS lease policies and to evaluate tracts prior to leasing. For a complete discussion of this alternative see Section VIII.J. of the Final EIS for Proposed Increase on Oil and Gas Leasing in the Outer Continental Shelf (USDI, 1975b, Vol. 2).

BIBLIOGRAPHY

IX. BIBLIOGRAPHY

Agermissen, S. T. 1969. Seismic risk studies in the United States. *In:* Fourth World Conference on Earthquake Engineering Santiago, Chile. Jan. 13-18.

A. H. Belo Corporation. 1973. Texas Almanac and State Industrial Guide 1974-75.

Allen, A. A. 1969. Statement to U.S. Senate Interior Committee, Subcommittee on Minerals, Materials and Fuels. May 20.

Allen, A. A., R. S. Schlucter, and P. J. Mikolaj. 1970. Natural oil seepage at Coal Oil Point, Santa Barbara, CA. Science 1970: 974-977. (Original reference not seen: cited by NAS 1975.)

American Association of Petroleum Geologists. 1972. Tectonic Map of Gulf Coast Region.

American Association of Petroleum Geologists. 1970. Bathymetric Map. Northern Gulf of Mexico.

American Petroleum Institute, American Gas Association and Canadian Petroleum Association. 1974. Reserves of Crude Oil Natural Gas Liquids and Natural Gas in the United States and Canada and United States Productive Capacity.

American Petroleum Institute, Independent Petroleum Association of American and Mid-Continent Oil and Gas Association. 1975. Joint Association Survey of the U.S. Oil and Gas Producing Industry.

Anderson, J. W. 1973. Uptake and depuration of specific hydrocarbons from oil by the bivalves, *Rangia cuneata* and *Crassostrea virginica*. *In:* Workshop in Inputs, Fates and Effects of Petroleum in the Marine Environment. Vol. 2. Ocean Affairs Board, NAS. Washington, D.C.

Antoine, J. W. 1972. Structure of the Gulf of Mexico. p. 1-34. *In:* Contributions on the Geological and Geophysical Oceanography of the Gulf of Mexico. Reazak and Henry (eds.). Gulf Publishing Company, Houston, Texas.

Arbingast, S. A. 1974. Texas Industry, 1973. Texas Business Review. Bureau of Business Research, Univ. of Texas, Austin.

Baker, J. J. 1971a. The effects of a single oil spillage. *In:* Proc. Ecological Effects of Oil Pollution on Littoral Communities. E. B. Cowell (ed.). Inst. of Petroleum, London.

Baker, J. J. 1971b. Successive spillages. *In:* Proc. of the Ecological Effects of Oil Pollution on Littoral Communities. E. B. Cowell (ed.). Inst. of Petroleum, London.

Battelle Memorial Institute. 1967. Oil spillage study; literature search and critical evaluation for selection of promising techniques to control and prevent damage. U.S. Dept. of Comm. Clg. Fed. Sci. Tech. Inf. Springfield, Va.

Battelle Memorial Institute. 1970. Review of Santa Barbara channel oil pollution incident. Wat. Poll. Cont. Res. Ser.

Bergantino, R. N. 1969. Map of the submarine physiography of the Gulf of Mexico. U.S. Naval Oceanographic Office, Washington, D.C. 20390.

Bergantino, R. N. 1971. Submarine regional geomorphology of the Gulf of Mexico. Geol. Soc. Am. Bull., 82(3):741-752.

Berryhill, H. L., Jr. 1975. Environmental assessment of the South Texas Outer Continental Shelf, Geologic Investigations, BLM Contract 08550-MU5-20. U.S. Geological Survey, trace metals content and surficial sediments.

Beynon, L. R. 1970. Oil spill dispersants. *In:* Proceedings, Symposium on Oil Spill Prevention. Institute of Petroleum, London, England. (Original reference not seen, cited by NAS 1975.)

Biglane, Kenneth E. U.S. Environmental Protection Agency. Personal communication. October 23, 1975.

Blokker, D.C. 1964. Paper presented to the Fourth International Harbor Conference, Antwerp, 22-27 June. (Original reference 1964 not seen; cited by USDI 1975d.)

Blumer, M. 1969a. Oil pollution of the ocean. p. 5-13. *In:* Oil on the Sea. D. P. Hoult (ed.). Plenum Press, New York.

Blumer, M., J. C. Robertson, J. E. Gordon and J. Sass. 1969b. Phytolderived C^{19} di- and triolefinic hydrocarbons in marine zooplankton and fishes. *Biochemistry* 8, 4067-4074.

Blumer, M., J. M. M. Mullin, and R. R. L. Guillard. 1970a. A polyunsaturated hydrocarbon (3,6,9,12,15-18-heneicosahexaene) in the marine food web. Mar. Biol. 6:226-235.

Blumer, M., G. Souza and J. Sass. 1970b. Hydrocarbon pollution of edible shellfish by an oil spill. Mar. Biol., 5:195-202.

Blumer, M., and others. 1971a. A small oil spill. Env. 13: 2-12.

Blumer, M. 1971b. Scientific aspects of the oil spill problem. Environmental Affairs, 1:54-73.

Blumer, M. 1972. Indigenous and petroleum-derived hydrocarbons in a polluted sediment. Mar. Poll. Bull. 3(6):92.

Bourne, W. R. P. 1968. Oil pollution and bird populations. *In:* Biological Effects of Oil Pollution on Littoral Communities. Pembroke, Wales.

Bogorov, V. G. et al. 1968. Atlas of the living resources of the seas. FAO. 1972.

Briggs, A. K. 1971. Archaeological resources in the Texas coastal lowland and littoral. Texas Historical Survey Committee, Texas Water Development Board.

Briggs, J. C. 1958. A list of Florida fishes and their distribution. Bull. Fla. State Museum, Biol. Sci., 2(8):223-318.

Bright, T. J. and C. W. Cashman. 1974. Fishes. p. 339-409. *In:* Biota of the West Flower Garden Bank. Gulf Publishing Company. Houston, Texas.

Bright, T. J. and H. Peguegnat. 1974. Biota of the West Flower Garden Bank, Gulf Publishing Co. Houston, Texas.

Brower, W. A., J. M. Meserve and P. G. Quayle. 1972. Environmental guide for the U.S. Gulf Coast. NOAA Environmental Data Service, National Climatic Center. Ashville, N. C. 177 p.

Burns, K. A. and J. M. Teal. 1971. Hydrocarbon incorporation into the salt-marsh ecosystem from the West Falmouth oil spill. Unpub. Manuscript. Woods Hole Ocean Inst. Ref. 71-69.

Busch, R. E. Jr., W. C. Ward, H. C. Skinner and E. B. Kemp III, 1974. Physiographic map of the Atchafalaya Basin and a portion of the Lower Red River Valley, Louisiana.

Busch, R. E. Jr. 1959. Observations on tropical marine fishes from the northeastern Gulf of Mexico. Quart. J. Fla. Acad. Sci., 22(1):69-74.

Busch, R. E. Jr. 1963. Tropical marine fishes in the Gulf of Mexico. Quart. J. Fla. Acad. Sci., 26(2):188-191.

Busch, R. E. Jr. and M. C. Caldwell. 1973. Marine mammals of the eastern Gulf of Mexico. p. III-1 to I-8. *In:* A Summary of Knowledge of the Eastern Gulf of Mexico. State Univ. Sys. Fla. Inst. Ocean., St. Petersburg, Florida.

Butler, J. N., B. F. Morris and J. Sass. 1973. Pelagic tar from Bermuda and the Sargasso Sea. Spec. Publ. No. 10. Bermuda Biological Station for Research, St. George's West. AD 769 873. (Original reference not seen; cited by NAS 1975.)

Button, D. K. 1971. Petroleum-biological effects in the marine environment. pp. 421-429. *In:* Impingement of Man on the Oceans, D. W. Hood (ed.). Wiley-Interscience. NY. (Original reference not seen; cited by NAS 1975.)

Canevari, E. P. 1971. Oil spill dispersants—Current status and future outlook, pp. 263-270. *In:* Proceedings, Joint Conference on Prevention and Control of Oil Spills. American Petroleum Institute, Washington, DC. (Original reference not seen; cited by NAS 1975.)

Causey, B. D. 1969. The fishes of Seven and One-Half Fathom Reef. MS Thesis. Texas A & M Univ. 110 p.

Charbreck, R. H. 1970. Vegetation and size of hydrologic units along the Louisiana coast. Report by La. Co-op. Wildl. Unit to U.S. Corps of Engineers and La. Wild. and Fisheries Comm., Baton Rouge, La.

Charbreck, R. H. 1972. Vegetation, water and soil characteristics of the Louisiana coastal region. La. State Univ. Agri. Expt. Sta., Baton Rouge, La. 72 p.

Charter, D. B., R. A. Sutherland, and J. D. Porricelli. 1973. Quantitative estimates of petroleum to the oceans. Nat. Aca. of Sci. Nat. Res. Coun. Washington, DC.
Clark, R. B. 1973. Impact of acute and chronic oil pollution on seabirds. *In:* Workshop on Inputs, Fates and Effects of Petroleum in the Marine Environment. Vol. 2. Ocean Affairs Board, Natl. Acad. Sci., Washington, D.C.
Clark, R. C. 1973. Biological fates of petroleum hydrocarbons in aquatic microorganisms. *In:* Workshop on Inputs, Fates and Effects of Petroleum in the Marine Environment. Vol. 2. Ocean Affairs Board, Nat. Acad. Sci., Washington, D.C.
Collard, S. B. and C. N. D'Asaro. 1973. Benthic invertebrates of the eastern Gulf of Mexico. *In:* A Summary of Knowledge of the Eastern Gulf of Mexico. J. I. Jones, R. E. Ring, M. O. Rinkel and R. E. Smith (eds.). State Univ. System Fla. Inst. Ocean. St. Petersburg, Florida.
Connel, D. W. 1971. Kerosene-like tainting in Australian mullet. Aust. Wine Res. Inst., So. Australia. Glen Osmond.
Corcoran, E. F. 1972. Data interpretation report of the study of the distribution and concentration of trace metals and pesticides of the Florida territorial sea of ESCAROSA: 1-71. Contract No. CCC-04-71 between SUSIO and FCCC.
Corner, E.D.S., C. C. Kilvington and S. C. M. O'Hare. 1973. Qualitative studies on the metabolism of naphtalene in *Mia squinado* (Herbst). J. Mar. Biol. Assoc. U.K., 53:819-832.
Council on Environmental Quality (CEQ). 1974. OCS oil and gas - an environmental assessment. Vol. 5. Washington, DC.
Cowell, E. B. 1969. The effect of oil pollution on salt marsh communities in Pembrokenshire and Cornwell. J. Appl. Ecol., 6:133-142.
Cowell, E. B. and J. M. Baker. 1969. Recovery of a salt marsh in Pembrokenshire, South-west Wales, from pollution by crude oil. Biol. Cons., 1:291-295.
Cowell, E. B. 1971. Some effects of oil pollution in Milford Haven, United Kingdom. pp. 429-436. *In:* Prevention and control of oil spills. Am. Pet. Inst. NY.
Crapp, G. B. 1971. Chronic oil pollution. *In:* Proc. Ecological Effects of Oil Pollution on Littoral Communities. E. B. Cowell (ed.) Inst. of Petr. London.
Curray, J. R. 1960. Sediments and history of Holocene Transgression; Continental shelf; Northwest Gulf of Mexico. p. 221-166. *In:* Recent Sediment, Northwest Gulf of Mexico. F. P. Shepard, F. P. Phleger and T. H. Van Andel, (ed.). Am. Assoc. Petrol. Geol.
Dahlberg, M. D. 1970. Atlantic and Gulf of Mexico Menhadens, genus Brevoortis (Pisces: Clupeidae). Bull. Fla. State Mus. Biol. Sci., 15(3):91-162.
Dawson, C. E. 1964. A revision of the Western Atlantic flatfish genus Gymnachirus (the naked soles). Copeia, 4:646-665.
Defaunt, A. 1961. Physical Oceanography. Vol. II. Pergamon Press. New York. 598 p.
Dennis, J. V. 1959. Oil pollution survey of the U.S. Atlantic coast special references to southeast Florida coast conditions. Am. Pet. Inst. Washington, DC. (Original reference not seen; cited in USDI 1972.)
Deuel, D. G. 1973. 1970 Salt-water angling survey. U.S. Dept. of Commerce, NOAA-NMFS, Current Fishery Statistics, NO. 6200, Wash., D.C. 54 p.
Dewling, R. T. 1971. Dispersant use and water quality. *In:* Proceedings, Joint Conference on Prevention and Control of Oil Spills. American Petroleum Institute, Washington, D.C. (Original reference not seen; cited by NAS 1975.)
Dinsmore, J. J. 1972. Sooty tern behavior. Bull. Fla. State Museum. 16:29-179.
Drinkwater, B., M. Leonard and S. Black. 1970. Santa Barbara's oiled birds. *In:* Biological and Oceanographic Survey of the Santa Barbara Channel Oil Spill, 1969-1970. Vol. 1, Biology and Bacteriology. D. Straughan (ed.). Sea Grant Pub. 2. Allen Hancock Foundation. Univ. Southern Calif., Los Angeles.
Duce, R. A., J. G. Quinn, C. E. Olney, S. R. Piortowicz, B. J. Ray, and T. L. Wade. 1972. Enrichment of heavy metals and organic compounds in the surface microlayer of Narragansett Bay, Rhode Island. Science 176:161-163. (Original reference not seen; cited by NAS 1975.)
Durham, D. L. and R. O. Reid. 1967. Analysis of the tidal current observations over the northeastern shelf of the Gulf of Mexico. Texas A & M Univ., Dept. of Ocean. College Station. 110 p.
Edwards, G. S. 1971. Geology of the West Flower Garden Bank. Texas A & M Univ.
Eleuterius, C. K. 1974. Mississippi superport study environmental assessment. Prepared for the Office of Science and Technology, Office of the Governor, State of Mississippi.
Ehrhardt, M. 1972. Petroleum hydrocarbons in oysters from Galveston Bay. Envir. Poll. 3:257-271.
El-Sayed, S. Z. 1972. Primary productivity and standing crop of phytoplankton in the Gulf of Mexico. *In:* Chemistry, Primary Productivity and Benthic Algae of the Gulf of Mexico. El-Sayed et al. (eds.). Serial Atlas of the Marine Environment, Folio 22 Amer. Geog. Soc., New York. 29 p. 6 Vols.
Environmental Protection Agency. 1974. Draft development document for effluent limitations guidelines and new source performance standards for the oil and gas extraction point source category. U.S. Environmental Protection Agency. October, 1974.
Estopinal, S. 1975. Personal communication. Louisiana Council of Underwater Diving Clubs.
Fay, J. A. and D. P. Holt. 1971. Physical processes in the spread of oil on a water surface. U.S. Coast Guard contract No. T-CG-01-381-A.
Fairbridge, R. W. 1960. The changing level of the sea. Sci. Amer.
Fanning, J. K. 1974. Nutrient analysis. Vol. 2 of 5. *In:* Draft Report of the Baseline Environmental Survey of the MAFLA Lease Areas. State Univ. Sys. of Fla. Inst. of Ocean., St. Petersburg, Fla.
Federal Energy Administration. 1976. Monthly Energy Review. National Energy Information Center, Washington, D.C.
Federal Power Commission News. 1973. Gas supply indicators. May 10, 1973. Washington, D.C.
Federal Power Commission News. 1975. Gas supply indicators, first quarter 1975. FPC News August 8, 1975. Washington, D.C.
Federal Register. 1975. Volume 40, Nos. 24, February 4; 63, April 1; and 88, May 6, 1975. Washington, D.C.
Federal Reserve Bank of Atlanta. 1972. Statistics on the developing South and additions. Research Department, Atlanta, Ga.
Federal Reserve Bank of Atlanta. 1975. Monthly Review, March 1975. Research Department. Atlanta, Ga.
Feldman, M. H. 1970. Trace materials in wastes disposed to coastal waters: Ecological guidance and control. Federal Water Pollution Control Administration. Pacific Northwest Water Laboratory Working Paper 78. Seattle, WA. (Original reference not seen; cited by NAS 1975.)
Ferme, Lt. Personal communication March 16, 1976. United States Coast Guard, Washington, D.C.
Filby, R. B. and K. R. Shah. 1971. Mode of occurrence of trace elements in petroleum and relationship to oil spill identification methods. *In:* Proceedings Am. Nuclear Society Meeting: Nuclear Methods in Environmental Research, J. R. Vogt, T. F. Parkinson and R. L. Carter (eds.), Univ. of Mo.
Fisher, W. L., L. F. Brown, Jr., J. H. McGowen and C. G. Grant. 1973. Environmental geologic atlas of the Texas coastal zone - Beaumont - Port Arthur area. Bur. of Econ. Geol. Univ. of Texas. 93 p.
Flawn, P. T. and B. Fisher. 1970. Land-use pattern in the Texas Coastal Zone. *In:* The Coastal Resources Management Programs of Texas. J. T. Goodwin and J. C. Mosely

(eds.). Coastal Res. Management Program, Office of the Governor, Austin, Tex.

Frazier, D. E. 1967. Recent Deltaic deposits of the Mississippi River: Their development and chronology. Transactions of the Gulf Coast Association of Geological Societies.

Gagliano, S. M., P. Light and R. Becker. 1971. Hydrologic and geologic studies of coastal Louisiana. Report No. 8. Controlled Diversions in the Mississippi Delta System. Coastal Studies Inst., La. State Univ. Baton Rouge, La.

Gagliano, S. M., P. Light and R. Becker. 1972. Proposed multiuse management plan for the Louisiana coastal zone. Coastal Res. Unit. Center for Wetland Res., La. State Univ. 27 p.

Gatteleir, C. R., J. L. Audin, P. Fusey, J. C. Lacaze, and M. L. Priou. 1973. Experimental ecosystems to measure fate of oil dispersed by surface active products, pp. 497-504. *In:* Proceedings, Joint Conference on Prevention and Control of Oil Spills. American Petroleum Institute, Washington, DC. (original reference not seen; cited by NAS 1975.)

General Accounting Office (GAO). 1973. Improved inspection and regulation could reduce the possibility of oil spills on the outer continental shelf. Report No. B-146333, June 1973.

Geological Survey of Alabama. 1971. Philip E. LaMoreaux, State Geologist. "Geology of Baldwin County, Alabama" Map 94, By Phillip C. Reed, University City, Alabama.

Gillespie, M. C. 1971. Analysis and treatment of estuarine waters of Louisiana. Section III, pp. 109-172. *In:* Cooperative Gulf of Mexico estuarine inventory and study, Louisiana. Louisiana Wildlife and Fisheries Commission. New Orleans, La.

Gould, H. R. and R. H. Steward. 1955. Continental terrace sediments in the northeastern Gulf of Mexico. Soc. Econ. Paleontol. and Min., Publ. No. 3. 129 p.

Grace, S. F. 1932. The principal diurnal constituent of tidal motion in the Gulf of Mexico. Monthly Notices, Royal Astron. Soc. Geophys. Suppl., 2(2):70-83.

Grady, J. R. 1970. Chart of distribution of sediment types - northern Gulf of Mexico. NOAA, NMFS, Gulf Coastal Fisheries Center.

Guinn, V. P. and S. C. Bellanca. 1970. Neutron activation analysis identification of the source of oil pollution of waterways. Spec. Publ. 321, Vol. 1, p. 185 ff. National Bureau of Standards, Gaithersburg, MD. (Original reference not seen; cited by NAS 1975.)

Gulf Universities' Research Consortium (GURC). 1974. The Offshore Ecology Investigation. Final report planning council consensus report, GURC Report No. 138. Galveston, Texas. 39 p.

Gunter, G. 1967. p. 621-638. *In:* Estuaries. G. H. Lauff (ed.), Pub. No. 83 AAAS, Washington, D.C.

Hannah, R. P. 1976. General Electric Company. NSTL Bay St. Louis, Mississippi. March 12,1976.

Hartung, R. 1965. Some effects of oiling on reproduction in ducks. J. Wildl. Mgmt., 29:872-874.

Hartung, R. and G. S. Hunt. 1966. Toxicity of some oils to waterfowl. J. Wildl. Mgmt., 39(3):564-570.

Hildebrand, H. L. 1954. A study of the fauna of the brown shrimp (Panaeus aztecus, Ives) grounds in the western Gulf of Mexico. Pub. Inst. Mar. Sci., Univ. of Texas 3(2):231-266.

Holland, W. C. 1970. Gulf of Mexico bathymetric map. Amer. Assoc. Petrol. Geol.

Holmes, R. W. 1969. The Santa Barbara oil spill, pp. 15-27. *In:* Oil on the sea. D. P. Hoult, (ed.). Plemun Press, New York, NY. (Original reference not seen; cited by NAS 1975)

Holmes, C. W. 1971. Zirconium of the continental shelf - possible indicator of ancient shoreline disposition. USGS Prof. Paper 750-C p. C7-C 12.

Holmes, C. W. 1973. Trace metal of the Gulf of Mexico USGS Map Series.

Hopkins, S. H. 1973. Aquatic life-nekton. *In:* Environmental Impact Assessment of Shell Dredging in San Antonio Bay, Texas. U.S. Army Engineer District. Galveston, Texas. 3:221-223.

Huan, Ter-Chien and H. G. Goodell. 1970. Sediments and sedimentary processes of eastern Mississippi Cove, Gulf of Mexico. AAPG, 54:2070:2100.

Hubbs, C. L. 1963. Chaetodon ays and related deep-living butterflyfishes: their variation, distribution and synonyms. Bull. Mar. Sci. Gulf Carib., 13(1):133-192.

Humm, H. J. 1973. The biological environment—seagrasses. p. III. C-1 to III C-10. *In:* A Summary of Knowledge of the Eastern Gulf of Mexico. J. I. Jones, R. E. Ring, M. O. Rinkel and R. E. Smith (eds.). State Univ. System of Fla. Inst. Oceanog. St. Petersburg, Fla.

Industrial Economic Research Division of Texas A & M University. 1972. Economic development study of the Texas Coastal Zone.

Jackson, G. A. 1972. A sport fishing survey of Biloxi Bay and the adjacent Mississippi Sound 1972. MS Thesis, Miss. State Univ.

James, W. P., R. W. Hann, Jr., D. R. Basco, et al. 1972. Report on the environmental aspects of a supertanker port on the Texas Gulf Coast. *In:* Sea Grant Program. W. P. James (ed.). Texas A & M Univ. NOAA. 420 p.

Jones, J. I., R. E. Ring, M. O. Rinkel and R. E. Smith. (eds.). 1973. A Summary of Knowledge of the Eastern Gulf of Mexico. Coordinated by State Univ. System of Fla. Inst. of Ocean. (SUSIO), St. Petersburg, Fla.

Jones, L. B. and G. R. Rice. 1972. An economic base study of coastal Louisiana. Center for Wetlands Res. La. State Univ., Baton Rouge.

Juhl, R. 1974. Fishery Resources - Commercial p. 211-226. *In:* Proc. Marine Environmental Implications of Offshore Drilling in the eastern Gulf of Mexico Jan. 31, to Feb. 2, 1974. SUSIO, St. Petersburg, Fla. 455 p.

Ketchum, B. H. 1973. Oil in the marine environment. *In:* Workshop on Inputs, Fates and Effects of Oil in the Marine Environment. Vol. 2. Ocean Affairs Board, Nat. Acad. of Sci., Washington, D.C.

Khromox, N. S. 1965. Quantitative distribution of plankton in the northwest part of the Caribbean Sea and in the Gulf of Mexico. VNIRO Trans. of the All-Union Scientific Research Inst. of Sea Fisheries and Oceanography. Vol. 57.

Kilgen, R. H. and A. H. Harris. 1973. Mariculture potentials in estuarine oil - pipeline canals. Proc. Gulf Carib. Fish. Inst. 23:75-80.

Kolb, C. R. and J. R. van Lopik. 1966. Depositional environments of the Mississippi River deltaic plain southeastern Louisiana. p. 17-61. *In:* Deltas. M. L. Shirley (ed.). Houston Geol. Soc.

Kolpack, R. L. 1971. Biological and Oceanographical Survey of the Santa Barbara Channel Oil Spill, 1969-1970. Vol. II. Physical, Chemical, and Geological Studies. Allan Hancock Foundation, University of Southern California, Los Angeles, CA. 477 pp. (Original reference not seen; cited by NAS 1975.)

Lafayette Geological Society. 1970. Offshore Louisiana oil and gas fields.

Lafayette Geological Society. 1973. Production trend map.

Lafayette Geological Society. 1973. Tectonic map of Louisiana.

Land, B. 1974. The toxicity of drilling fluid components to aquatic biological systems. Tech. Rpt. No. 487. Fisheries and Marine Service. Environment Canada. Winnipeg, Manitoba, Canada.

Leary, J. F. 1975. High seas oil recovery systems development and testing. *In:* Proc. 1975 Offshore Tech. Conf., Houston, Texas.

Lee, R. F., R. Sauerheber and A. A. Benson. 1972. Petroleum hydrocarbons: uptake and discharge by the marine mussel *Mytilus edulis*. Science, 117-344-346.

Lee, R. F. and A. A. Benson. 1973. Fate of Petroleum in the sea: biological aspects p 54-551. *In:* report from workshop on Inputs, Fates and the Effects of Petroleum in the Marine Environment, Ocean Affairs Board, NAS, Washington, D.C.

Lehner, P. 1969. Salt tectonics and pleistocene stratigraphy on continental slopes of northern Gulf of Mexico. Am. Assoc. Petrol. Geol. Bull. 53:2431-2479.

Leibovick, S. 1975. Hydronamic problems in oil spills control and removal. *In:* Proc. 1975 Offshore Tech. Conf. Houston, Texas.

Leipper, D. F. 1954a. Marine meteorology of the Gulf of Mexico a brief review. *In:* Gulf of Mexico, Its Origin, Waters and Marine Life. P. S. Galtsoff (ed.) Fisheries Bulletin. No. 89, Fish and Wildlife Service, U.S. Dept. of the Int., Washington, D.C. 58:89-98.

Leipper, D. F. 1954b. Physical oceanography of the Gulf of Mexico. *In:* Gulf of Mexico, its origin, waters and marine life. P. S. Galtsoff (ed.). Fishery Bulletin 89. Fish and Wildlife Service, U.S. Dept. of the Int., Washington, D.C. 55:119-138.

Logan, B. W. 1969. Carbonate sediments and reefs Yucatan shelf, Mexico. Jour. Geophys. Res. 75(3):638-657.

Louisiana Advisory Commission on Coastal and Marine Resources. 1972. Louisiana Government and the Coastal Zone—1972. Baton Rouge, La.

Louisiana Advisory Commission on Coastal and Marine Resources. Louisiana Wetlands Prospectus. Baton Rouge, La.

Louisiana Air Control Commission. 1972. Louisiana implementation plan. Louisiana Air Control Commission. New Orleans, La.

Louisiana Department of Employment Security. 1975. Labor Area Trends, February, 1975. New Orleans, La.

Louisiana Planning Corporation, in cooperation with Planning Systems Corporation. 1972. Initial Elements Toward a Comprehensive State Plan, Two Volumes, Baton Rouge, La.

Lower Mississippi Region Comprehensive Study, Lower Mississippi Region Comprehensive Study Coordinating Committee. 1974. Mississippi River Commission, Corps of Engineers. Vicksburg, Miss.

Lowery, G. H., Jr. 1960. Louisiana Birds. La. State Univ. Baton Rouge. 567 p.

Ludwig, H. F., and R. Carter. 1961. Analytical characteristics of oil-tar materials on Southern California beaches. J. Water Pollut. Control Fed. 33:1123-1139. (Original reference not seen; cited by NAS 1975).

Mackin, J. G. 1973. A review of significant papers on effect of oil spills and oil field brine discharges on marine biotic communities. Texas A & M Univ. Res. Found. Project 737. Texas A & M Univ.

Manheim, F. 1974. Scientific Summary. *In:* Final Report on the Baseline Environmental Survey of the MAFLA Lease Areas. State Univ. System of Fla. Inst. of Ocean., St. Petersburg, Fla.

Massachusetts Institute of Technology. 1973. Georges Bank petroleum study. Offshore oil task group. Sea Grant Prof. Off. Rept. No. MITSG 73-5. Cambridge, MA.

Massachusetts Institute of Technology. 1974. Analysis of oil spills. Prepared for Coun. Envir. Qual. Washington, D.C.

McGovern, J. C., C. G. Groat, L. F. Brown, W. L. Fisher and A. J. Scott. 1970. Effects of hurricane "Celia" — a focus on environmental geology problems of the Texas Coastal Zone. Geol. Circ. 70-3. Bur. Econ. Geol., Univ. of Texas. Austin, Texas 35 p.

Menzies, R. J. 1973. Recorded oil spills in the O.E.I. area. Presented at the Gulf University Research Consortium meeting, Oct., 1973. Tampa, Fla.

Mills, E. R., Jr. 1974. Effects of water dispersions and water-soluble fractions of two crude and two processed oils on three marine algae species. Ph.D. Dissertation. Texas A & M Univ. 95 p.

Mironov, O. G. 1969. Viability of some crustacea in the sea-water polluted with oil products. Zool. Zh. 68(1):1731. (Original reference not seen; cited by NAS 1975).

Mironov, O. G. 1970. The effect of oil pollution on flora and fauna of Black Sea. *In:* Atlas of the Living Resources of the Sea. FAO Department of Fisheries. Rome, Italy.

Mitchell, C. T. and others. 1970. What oil does to ecology. Jour. W.P.C.F. Part I. 42(5):812-818.

Moore, S. F., G. R. Chirlin, C. J. Puccia and B. P. Schrader. 1974. Potential biological effects of hypothetical oil discharged in the Atlantic coast and Gulf of Alaska. Mass. Inst. of Technol., Sea Grant Project Office. Rept. MITSG-74-19.

Moore, S. F., R. L. Dwyer and A. M. Katz. 1973. A preliminary assessment of the environment vulnerability of Machias Bay marine organisms to oil supertankers. Ralph M. Parsons Lab. for Water Res. and Hydrodynamics, Mass. Inst. of Technol. Cambridge, Mass.

Moseley, F. N. 1966. Notes on fishes from the snapper banks off Port Aransas, Texas. Tex. J. Sci. 18(1):75-79.

Murphy, T. A. and L. T. McCarthy. 1970. Evaluation of the effectiveness of oil dispersing chemicals. *In:* Proceedings, Industry-Government Seminar on Oil Spill Treating Agents. Am. Petrol. Inst. Publ. 40:55. (Original reference not seen; cited by NAS 1975).

Murray, S. P., W. G. Smith, and C. J. Soner. 1970. Oceanographic observations and theoretical analysis of oil slicks during the Chevron spill Mar. 1970. Coastal Studies Inst. Tech. Rept. No. 87. La. 107 pp.

National Academy of Science (NAS). 1973. Background papers for a workshop on inputs, fates, and effects of petroleum in the marine environment. Volumes I and II. Washington, D.C.

National Academy of Sciences (NAS). 1975. Petroleum in the marine environment. 107 pp.

National Petroleum Council. 1974. Availability of materials, manpower and equipment for exploration, drilling production of oil—1974-1976. Washington, D.C.

Naval Oceanographic Office. 1955. Atlas of Pilot Charts, Central American Waters and South Atlantic Ocean. Second Edition.

Nelson-Smith, A. 1973. Oil Pollution and Marine Ecology. Plenum Press, N. Y.

Newton, M. B., Jr. 1972. Atlas of Louisiana, a guide for students, School of Geoscience, Misc. Publ. 72-1, La. State Univ. Baton Rouge, La.

North, W. J., M. Neushul, and K. A. Clendenning. 1964. Successive biological changes observed in a marine cove exposed to a large spill of mineral oil. pp. 335-354. Symp. Poll. mar. Micro-org. Prod. petrol. Monaco.

Nowlin, W. D. 1971. Water masses and general circulation of the Gulf of Mexico. Oceanology 6(2):28-33.

Nowlin, W. D. 1972. Winter circulation patterns and property distributions. pp. 3-51. *In:* L.R.A. Capurro and J. L. Reed (eds.). Contributions on the physical oceanography of the Gulf of Mexico. Texas A & M University. Oceanographic Studies. Vol. II. Gulf Publishing Co. Houston, Texas.

Odum, E. P. 1971. Fundamentals of Ecology. W. B. Saunders Co., Philadelphia.

Oil and Gas Journal. 1974. Annual Refining Survey. Aileen Cantrell, Director of Editorial Surveys. April 1, 1974.

Operations Oil. 1970. Report of the task force - Operation Oil (cleanup of the Arrow oil spill in Chedabucto Bay) to the Minister of Transport. Atlantic Ocean Lab. Bedford Inst. Dartmouth, Nova Scotia.

Orton, R. B. 1974. The climates of Texas and adjacent Gulf waters. U.S. Department of Commerce, Weather Bureau, Washington, D.C.

Ottway, S. M. 1970. The comparative toxicities of crude oils. *In:* Proceedings, Symposium on the Ecological Effects of Oil Pollution on Littoral Communities, E. B. Cowell (ed.). Institute of Petroleum, London, England. (Original reference not seen; cited by NAS 1975).

Palmisano, A. W. 1972. Habitat preference of waterfowl and fur animals in northern Gulf coast marshes. *In:* Proc. of the Coastal Marsh and Estuary Management Symp. La. State Univ. Baton Rouge, La.

Parker, R. H. 1960. Ecology and distributional patterns of marine macro-invertebrates, northern Gulf of Mexico. *In:* Recent Sediments, Northwest Gulf of Mexico. F. P. Shepard et al. (eds.). Amer. Assoc. Petrol. Geol., Tulsa, Oklahoma. p. 302-337.

Parker, R. H. and J. R. Curray. 1956. Fauna and bathymetry of banks on the continental shelf, Gulf of Mexico. Bull. Amer. Assoc. Petrol. Geol. 40:2428-2439.

Peak, J. S. and A. Muller, 1971. Fog in Louisiana hydroclimatology.

Peller, E. 1963. Operation duck rescue. Audubon, 65; 364-367.

Pennak, R. W. 1964. Collegiate Dictionary of Zoology. The Ronald Press Co. New York.

Porricelli, J. D. and V. F. Keith. 1973. Tankers and the U.S. energy situation. An economic and environmental analysis. For presentation at the Int. Trans. Conf. Denver, Co. Sept. 24-27, 1973, of the Intersoc. Comm. on Trans.

Quinn, J. G., and T. L. Wade. 1972. Lipid measurements in the marine atmosphere and sea surface microlayer, pp. 633-664. Background paper for Brookhaven (24-26 May 1972) workshop on baseline studies of pollutants in the marine environment. *In:* International Decade of Ocean Exploration. E. D. Goldberg, (ed.). National Science Foundation. Washington, D.C. (Original reference not seen; cited by NAS 1975).

Randall, J. E. 1968. Caribbean Reef Fishes. TFH Publications, Inc., New Jersey.

Raun, G. G. and F. R. Gelback. 1972. Amphibians and reptiles in Texas. Bulletin 2. Dallas Mus. of Natl. Hist. and Natl. Sci. Assoc. Dallas, Texas 61 p.

Ray, S. M. and E. R. Mills, Jr. 1974. Effects of oil on phytoplankton. *In:* Fate and Biological Effects of Oil in the Marine Environment. Amer. Petrol. Inst., Washington, D.C. May 29-30, 1974.

Raymont, J. E. G. 1963. Plankton and primary productivity in the oceans. Pergamon Press Ltd. Oxford, England.

Renfro, H. B. 1973. AAPG-U.S. geological highway map for Texas. No. 7. AAPG, P. O. Box 979. Tulsa, Oklahoma 74101.

Revelle, R., E. Wenk, B. H. Ketchym, and E. R. Corino. 1971. Ocean pollution by petroleum hydrocarbons. pp. 297-318. *In:* Man's Impact on Terrestrial and Oceanic Ecosystems. W. H. Matthews, F. E. Smith, and E. D. Goldberg, (eds.). MIT Press, Cambridge, Mass. (Original reference not seen; cited by NAS 1975).

Ridgely, Jr. 1975. Selected information on recreational boats in the United States. Marine Fisheries Review, Paper 1122, 37(2):16-18.

Rittinghaus, H. 1956. Etwas uber die "indirekete" Verbreitung der Olpest In einem Seevogelschutzgegeite. Ornithol. Mitt. Lubeck, 3:43-46. *In:* Oil and Pollution and Marine Ecology. Nelson-Smith (ed.) 1973.

Robichaux, T. J. 1975. Bactericides and the drilling and completion operations. Conf. on Environmental Aspects of Chemical Use in Well-drilling Operations. Houston, Texas. 11 pp.

Rogers, W. F. 1963. Composition and properties of oil well drilling fluids. Gulf Publishing Co. Houston, Texas.

Rona, E., D. Hood, L. Muse and B. Buglio. 1962. Activation analysis of manganese and zinc in seawater. Limnol. and Oceanogr., 7:201-206.

Rutzler, K. and W. Sterrer. 1970. Oil pollution: Damage observed in tropical communities along the Atlantic seaboard of Panama. Bioscience 20(40):222-224.

Ryan, J. J. 1969. A sedimentological study of Mobile Bay, Alabama. Sed. Res. Lab. Fla. State Univ. Contr. 30, 110 p.

Ryan, R. J. 1973. Texas Manufacturing. Texas Almanac and State Industrial Guide. 1974-75. A.H. Belo Corp.

Sackett, W. M. 1972. Chemistry. p. 1-4. *In:* Chemistry, Primary Productivity and Benthic Algae of the Gulf of Mexico. V. C. Bushnel (ed.). Serial Atlas of the Marine Environment. Folio 22. Amer. Geog. Soc., New York.

Sanders, H. L., J. F. Grassle, and G. R. Hampson. 1972. The West Falmouth oil spill. Part I. Biology. Woods Hole Ocean. Inst. Tech. Rep. No. WHOI-72-20. 49 pp.

Scarratt, D. J. 1971. Incidence of Bunker C in common benthic animals and sediment. p. 4-12. *In:* Contrib. Oil. Pollut. Workshop. Nova Scotia Technical College, Halifax.

Schmidly, D. J. and B. A. Melcher. 1974. Series of three articles on marine mammals in the Gulf of Mexico. Texas Parks and Wildlife. Vol. 1, 2 and 3.

Scruton, P. C. 1956. Oceanography of the Mississippi Delta sedimentary environments. Am. Assoc. of Petrol. Geol. Bull., 40(12):2864-2952.

Shelton, R. G. J. 1972. Effects of oil dispersants on the marine environment. Proc. Roy. of London, 177:411.

Shepard, P. 1960. Recent sediment, N. W. Gulf of Mexico. AAPG. Tulsa, Okla. 394 p.

Shinn, E. A. 1974. Oil structures as Artificial Reefs. *In:* Proc. Artificial Reef Conference, Texas A & M Univ., Nat. Mar. Fish. Ser.; Texas Coastal Mar. Coun., Houston, Texas.

Simpson, A. C. 1968. *In:* The Biological Effects of Oil Pollution on Littoral Communities. J. D. Carthy and Dr. R. Arthyr (eds.). Field Studies Council, London.

Slowey, J. F. and Hood, D. W. 1969. Copper, manganese and zinc concentrations in the Gulf of Mexico waters. Geochim et Cosmochim. Acta, 35:121-138.

Smith, F. M. 1975. Statement of Forest Smith, representing the Western Oil and Gas Association before the U.S. Department of the Interior, Bureau of Land Management Public Hearing in the Draft Environmental Statement for the Proposed 1975 OCS oil and gas general lease sale offshore So. California, May 7, 1975. Los Angeles, Calif.

Smith, G. B. (ND). Distribution and ecology of mid-eastern Gulf of Mexico reef fishes. Fla. Mar. Res. Pub., In press.

Smith, G. B. et al. (ND) Fishes of the Florida Middle Ground with comments on ecology and zoogeography. Fla. Mar. Res. Pub., In press.

Smith, J. E. (ed.) 1968. *Torrey Canyon* pollution and marine life. Plymouth Lab. of the Mar. Biol. Asso. of U. K. Cambridge Univ. Press. London, England. 189 pp.

Snow, G. W. 1975. Personal communication to Mr. C. J. Nettles. June 18, 1875. Louisiana Shrimp Association, New Orleans, La.

Sonnier, F., J. Terrling and H. D. Hoese. (ND). Observations on the offshore reef and platform fish fauna of Louisiana. Copeid, In press.

Sonu, C. J., S. P. Murray, S. A. Hsu, J. N. Shuayda and E. Waddel. 1973. EOS. Trans. of AGU 54:9.

Springer, V. G. 1959. Blenniid fishes of the genus *Chasmodes*. Texas J. of Sci., 11(1):321-334.

St. Amant, L. S. 1974. Written statement for public hearing on proposed Louisiana OCS Oil and gas lease. New Orleans, La. June 5, 1974

Standard Industrial Classification Manual. 1972. Office of Management and Budget, Executive Office of the President. Washington, D.C.

Steidinger, K. A. 1973. The biological environment-phytoplankton. p. III F-1 to III F-18. *In:* A Summary of the Knowledge of the Eastern Gulf of Mexico. J. I. Jones, R. E. Ring, M. O. Rinkel and R. E. Smith (eds.). State Univ. Systems Fla. Inst. Ocean., St. Petersburg.

Stone, J. H. 1972. Preliminary assessment of the environmental impact of a superport on the southeastern coastal area of Louisiana. LSU Sea Grant Publ. No. 72-05. Baton Rouge, La.

Straughan, D. 1970. Biological and oceanographical survey of the Santa Barbara Channel oil spill, 1969-1970. Vol. I, Biology and Bacteriology. Vol. II. Physical, chemical and geological studies. Allan Hancock Foundation, Univ. of Southern California.

Straughan, D. 1972. Factors causing environmental changes after an oil spill. pp. 250-254. Jour. Pet. Tech.

Struzewski, E. J. and R. T. Dewling. 1969. Chemical treatment of oil spills, pp. 217-222. *In:* Proceedings Joint Conference on Prevention and Control of Oil Spills. American Petroleum Institute, Washington, D.C. (Original reference not seen; cited by NAS 1975).

Sweet, W. E. 1974. Surface current study. NW Gulf of Mexico, A study of naturally occurring hydrocarbon in the Gulf of Mexico. Texas A & M Report.

Teal, J. M. and J. J. Stegeman. 1973. Accumulation and release of petroleum hydrocarbons by the oyster Crassostrea virginica. p. 571-602. *In:* Proc. Workshop on Inputs, Fates and the Effects of Petroleum in the Marine Environment, Ocean Affairs Board, NAS Washington, D.C.

Teknekron, Inc. 1973. Fuel cycles for electrical power generation, phase I: towards comprehensive standards: the electric power case. Office of Research and Monitoring, EPA. Berkeley, Calif.

Texas Air Control Board. 1973. Texas implementation plan. Texas Air Control Board. Austin, Texas.

Texas Air Control Board. 1975. Personal communication, Larry Butts, Air Quality Evaluation Division, Austin, Texas.

Texas A & M University. 1972. Environmental aspects of a supertanker port on the Texas Gulf Coast. Texas A & M Univ. Sea Grant College Program. College Station, Texas. 445 p.

Texas A & M University. 1973. A summary report. Economic Development in the Texas costal zone. Texas A & M University Sea Grant Program. College of Engineering, College Station, Tex. 72p.

Texas Archaeological Research Laboratory. 1974. Report on the cultural resources of the Texas coastal zone. Univ. of Texas, Austin. 12 Volumes.

Texas Business Review. 1975. Bureau of Business Research, University of Texas. Austin, Texas.

Texas Parks and Wildlife Department. 1974. Comprehensive outdoor recreation on the Texas Gulf coast. Texas Outdoor Recreation Plan, (preliminary draft), Austin, Texas 4:27.

Thomas, M. L. H. 1973. Effects of Bunker oil on intertidal and lagoonal biota in Chedabucto Bay, Nova Scotia. J. Fish. Res. Bd. Canada, 30(1):83-90.

Turner, Collie and Braden, Inc., Consulting Engineers. 1966. Comprehensive study of Houston's municipal water system for the city of Houston, Phase I Basic Studies. 50 p.

Uchupi, E. 1967. Bathymetry of the Gulf of Mexico. Trans. Gulf Coast Assoc. of Geol. Soc., 18:161-172.

Uchupi, E. and K. O. Emery. 1968. Structure of continental margin off the Gulf coast of the United States. Bull Amer. Assoc. Petrol. Geol., 52(7):1162-1193.

U.S. Department of the Army. 1971. National Shoreline Study Inventory Report-Lower Mississippi Region. New Orleans District Corps of Engineers, New Orleans, La. 90 p.

U.S. Department of the Army. 1972. Physiographic overview of South Louisiana Atlas Inventory of Basic Environmental Data. U.S. Army Corps of Engineers, New Orleans, La.

U.S. Department of the Army. 1973. Report on Gulf Coast deep water port facilities - Texas, Louisiana, Mississippi, Alabama and Florida. Corps of Engineers, Lower Mississippi Valley Division, Vicksburg, Miss.

U.S. Department of Commerce. 1967. United States Coast Pilot 5. Atlantic Coast, Gulf of Mexico, Puerto Rico and Virgin Islands (6th Ed.) U.S. Coast and Geodetic Survey, Environmental Science Services Administration, Washington, D.C. 301 p.

U.S. Department of Commerce. 1968. Climatic Atlas of the United States. ESSA. Environmental Data Service, Washington, D.C. 80 p.

U.S. Department of Commerce. 1970. General social and economic characteristics. Bureau of the Census, Washington, D.C.

U.S. Department of Commerce. 1973. 1970 saltwater angling survey, CFS No. 6200. National Marine Fisheries Service. Washington, D.C.

U.S. Department of Commerce. 1974. Area Economic Projections 1900, Government Printing Office, Washington, D.C. 237 p.

U.S. Department of Commerce. 1975. Fisheries of the United States, 1974. Current Fisheries Statistics No. 6700, National Marine Fisheries Service, Washington, D.C. 98 p.

U.S. Department of the Defense. 1975. Comments received from Deputy Assistant. Secretary of Defense (Environmental Quality) October 23, 1975.

U.S. Department of the Interior. 1969. Bureau of Commercial Fisheries, Washington, D.C.

U.S. Department of the Interior. 1970. Bureau of Commercial Fisheries, Washington, D.C.

U.S. Department of the Interior, 1972. Final Environmental Impact Statement Proposed Trans-Alaska Pipeline. Washington, D.C.

U.S. Department of the Interior. 1973a. Minerals Yearbook, Bureau of Mines, Washington, D.C.

U.S. Department of the Interior. 1973b. Natural gas production and consumption. Bureau of Mines.

U.S. Department of the Interior. 1973c. Petroleum refineries Annual, Bureau of Mines.

U.S. Department of the Interior. 1973d. National Wildlife Refuges in the Southeast Region 4, Fish and Wildlife Service, Refuge Leaflet 67-4, GPO, Washington, D.C.

U.S. Department of the Interior. 1974a. Environmental impact statement. Volumes 1-3. OCS Sale No. 34. Bureau of Land Management.

U.S. Department of the Interior. 1974b. Final environmental impact statement. Volumes 1-3. OCS Sale No. 36. Bureau of Land Management.

U.S. Department of the Interior. 1974c. Final environmental impact statement Volumes 1-4. OCS Sale No. 37, Bureau of Land Management.

U.S. Department of the Interior. 1974d. Energy Alternatives and their Related Environmental Impacts, Bureau of Land Management, Washington, D.C.

U.S. Department of the Interior. 1974e. National Park Service. The National Register of Historical Places, Washington, D.C.

U.S. Department of the Interior. 1974f. Natural gas annual, Bureau of Mines, Washington, D.C.

U.S. Department of the Interior. 1974g. U.S. Fish and Wildlife Service, United States list of endangered fauna. Washington, D.C.

U.S. Department of the Interior. 1974h. Petroleum Statement Monthly, Bureau of Mines, Washington, D.C.

U.S. Department of the Interior. 1974i. Santa Barbara Channel. Santa Ynez Unit. Final EIS. U.S. Geological Survey, Washington, D.C.

U.S. Department of the Interior. 1974j. Seabird Surveys, Cape Lisburne to the Barren Islands, Alaska. Unpubl. Prog. Rept.

On file at U.S. Fish & Wildlife Service. Anchorage, Alaska 17 pp.

U.S. Department of the Interior, Bureau of Mines. 1975a. Crude Petroleum, Petroleum Products, and Natural Gas Liquids. April 1975.

U.S. Department of the Interior, Bureau of Land Management. 1975b. Final Environmental Impact Statement. OCS Sale No. 41. Volumes 1-3.

U.S. Department of the Interior, Bureau of Land Management. 1975c. Final Environmental Impact Statement. Volumes 1-3. Proposed Increase in Oil and Gas Leasing on the Outer Continental Shelf.

U.S. Environmental Protection Agency. 1975. Compilation of Air Pollutant Emission Factors. Research Triangle Park, N. C.

U.S. Federal Highway Administration. 1971. Highway statistics. Washington, D.C.

U.S. Geological Survey. 1974. Production trend map of Gulf of Mexico. USGS, Conservation Division, Gulf of Mexico - OCS Operations, Metairie.

U.S. Geological Survey. 1976. Outer Continental Shelf Statistics. March 1976. USGS Conservation Division, New Orleans, La.

U.S. Water Resources Council. 1972. OBERS Projections. Economic activity in the United States. Vol. 1. Concepts Methodology and Summary Data. Government Printing Office, Washington, D.C. 109 p.

U.S. Water Resources Council. 1974. 1972 OBERS Projections, Series E Population, Washington, D.C.

Valentine, J. M. and R. E. Noble. 1970. A colony of sandhill cranes in Mississippi. Jour. Wildl. Mgmt. 34(4)761-768.

Vaughn, B. E. (ed.). 1973. Effects of oil and chemically dispersed oil on selected marine biota—a laboratory study. Prepared by Battelle Northwest Laboratories, Richland, Washington. Prepared by Amer. Petrol. Inst. Publ. No. 4191, Washington, D.C.

Vernon and Puri. 1964. Geologic map of Florida. Published by Florida Board of Conservation, Division of Geology, Tallahassee, Florida.

Walls, J. G. 1973. Noteworthy marine fishes from eastern Louisiana. Quart. J. Fla. Acad. Sci., 35(2)109-112.

Whitehorn, C. 1973. Economic analysis of the petrochemical industry in Texas. Industrial Economics Research Division, Texas A & M Univ.

Widner, D. 1975. Personal communication. Assistant Manager of the Delta-Gulf Island National Wildlife Refuge.

Wilhelm, O. and M. Ewing. 1972. Geology and history of the Gulf of Mexico. Geol. Soc. Am. Bull., 83:575-600.

Williams, L. E. 1965. Jaegers in the Gulf of Mexico. Auk 82:19-25.

Woolfenden, G. E. and R. E. Schreiber. 1973. The common birds of the saline habitats of the eastern Gulf of Mexico; their distribution, seasonal status and feeding ecology. p. IV J-1 to III-J-22. *In:* A Summary of Knowledge of the Eastern Gulf of Mexico. State Univ. Sys. Fla. Inst. Ocean. St. Petersburg.

Wragg, L. E. 1954. Effects of DDT and oil on muskrats. Canadian Field Nat., 68:11-13.

Yerger, R. W. 1961. Additional records of marine fishes from Alligator Harbor, Florida and vicinity. Quart J. Fla. Acad. Sci., 24(2):111-116.

Zlatkovich, P. Texas Construction, Texas Business Review December, 1975. University of Texas, Austin, Texas.

Zsolnay, A. 1973. Hydrocarbon and chlorophyll: a correlation in the upwelling region off West Africa. Deep Sea. Res. 20:923-925. (Original reference not seen; cited by NAS 1975).

X APPENDIX

APPENDIX A

List of Tracts for Proposed Lease Sale #44

Tract Number	Block	Description	Type/ Res.	Acreage	Distance From Shore (S.Miles)	Water Depth (Meters)
Brazos Area, South Addition (BS)						
1	A-104	All	II/G	5760	22	57
Galveston Area (G)						
2	144	All	II/G	5760	11	14
High Island Area (HI)						
3	109	All	I/O&G	5760	14	14
4	141	E½	I/G	2880	15	15
High Island Area, East Addition (HIE)						
5	A-228	All	II/G	5760	34	27
High Island Area, East Addition, South Extension (HES)						
6	A-281	All	II/G	5760	44	52
7	A-310	All	II/G	2908	50	64
West Cameron Area (WC)						
8	69	S½	I/G	2500	9	11
9	103	All	I/G	5000	12	12
10	134	E½	I/G	2500	18	12
11	170	E½	I/G	2500	22	11
12	264	All	II/G	5000	42	24
13	279	All	I/G	5000	48	27
West Cameron Area, South Addition (WCS)						
14	455	All	II/G	5000	67	36
15	459	All	II/G	5000	64	39
16	460	All	II/G	5000	71	39
17	506	All	I/G	5000	77	43
18	507	S½	I/G	2500	79	46
19	528	All	I/G	5000	90	54
20	539	All	I/G	5000	98	75
21	601	All	II/G	5000	109	78

Tract Number	Block	Description	Type/ Res.	Acreage	Distance from Shore (S.Miles)	Water Depth (Meters)
East Cameron Area, South Addition (ECS)						
22	333	All	II/G	5000	100	75
23	336	All	II/G	5000	103	78
24	340	All	I/G	5000	101	78
Vermilion Area (V)						
25	25	All	I/G	5000	5	8
26	37	All	I/G	5000	7	11
27	50	All	I/G	4605.36	8	5
28	102	All	II/G	4587.70	24	20
29	146	All	I/G	5000	32	24
30	156	All	I/G	5000	34	25
31	160	SW¼	I/G	1250	35	27
32	163	NW¼	I/G	1250	38	28
Vermilion Area, South Addition (VS)						
33	277	All	II/G	5000	76	55
34	286	All	II/G	5000	78	57
35	310	All	I/G	5000	83	63
South Marsh Island Area (SMI)						
36	8	All	I/O&G	3146.45	30	20
South Marsh Island Area, South Addition (SMS)						
37	183	All	I/G	3509.89	98	114
South Marsh Island Area, North Addition (SMN)						
38	273	All	II/G	5000	27	12
39	276	All	II/G	5000	32	15
Eugene Island Area (EI)						
40	37	1/	I/G	419.12(E)	3	3
41	229	All	I/G	5000	40	37
Eugene Island Area, South Addition (EIS)						
42	301	N½	II/G	2500	62	61
43	302	All	II/G	5000	62	67
44	310	All	II/O&G	5000	62	68
45	311	All	II/O&G	5000	70	67
46	351	All	II/G	5000	72	90
47	352	All	II/G	5000	72	86

Tract Number	Block	Description	Type/ Res.	Acreage	Distance from Shore (S. Miles)	Water Depth (Meters)
Ship Shoal Area (SS)						
48	15	1/	I/G	1311.14(E)	3	3
49	36	NW¼	I/G	1250	3	3
50	111	All	II/G	5000	17	10
51	213	All	I/O&G	5000	32	33
52	232	All	I/O&G	5000	34	38
South Timbalier Area (ST)						
53	182	All	I/O&G	2148.46	33	38
West Delta Area (WD)						
54	34	N½	I/O&G	2500	10	18
55	47	All	I/O&G	5000	10	13
South Pass Area (SP)						
56	57	2/	I/O	877.49	4	55
Main Pass Area (MP)						
57	72)	3/			6	36
	74)	3/	I/O	3869.18	5	43
58	114	All	II/G	4994.55	11	16
59	116	All	II/G	4994.55	11	15
Main Pass Area, South & East Addition (MSE)						
60	160	All	II/G	4994.55	21	37
Mobile South No. 2 (MS2)						
61	N658 E47	All	I/G	2178.08	31	200

1/ That portion located seaward of the Supreme Court Decree Line of June 16, 1975 (U.S. vs Louisiana, 422 U.S. 13).

2/ That portion of Block 57 seaward of a line three geographical miles from and parallel to the First Supplemental Decree Line (382 U.S. 288; Dec. 13, 1965).

3/ That portion of Blocks 72 and 74 located seaward of the Supreme Court Decree Line of June 16, 1975 (U.S. vs Louisiana, 422 U.S. 13), to the Third Supplemental Decree Line (404 U.S. 388 (December 20, 1971)).

Key to Type/Reservoir:

Type I - drainage tract, Type II - development tract and Type III - wildcat tract.

Reservoir: G-gas, O-oil and O&G-oil and gas.

Bureau of Land Management
Library
Denver Service Center

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225